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IRON and STEEL ENGINEER

FUEL — ELECTRICITY — MACHINERY — METHODS

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To Educate the Engineer in Industry

AUGUST, 1924

Containing the Proceedings of the A.I.&S.E.E.

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Iron and Steel Exposition

Electrically Driven Reversing Mills
By J. D. WRIGHT, Electrical Engineer, General Electric Company, Schenectady, N. Y.; R. W. DAVIS, Electrical Engineer, Allis Chalmers Manufacturing Company, Milwaukee, Wis., and O. H. NEEDHAM, Electrical Engineer, Westinghouse Electric & Mfg. Company, East Pittsburgh, Pa.

Engine vs. Motor Drive for Reversing Blooming Mill
By C. H. HUNT
Chief Engineer, Weirton Steel Company
Wheeling, W. Va.

Discussion in Connection with Heating Furnaces
By A. F. MITCHELL
Fuel and Metallurgical Engineer, Surface Combustion Company
Pittsburgh, Pa.

Modern Methods of Lubrication as Applied to Cranes in Steel Mills
By H. E. THOMPSON
District Manager, S. F. Bowser & Company, Inc.
Cleveland, Ohio

The Freret Safety Enclosed Knife Switch
By A. L. FRERET
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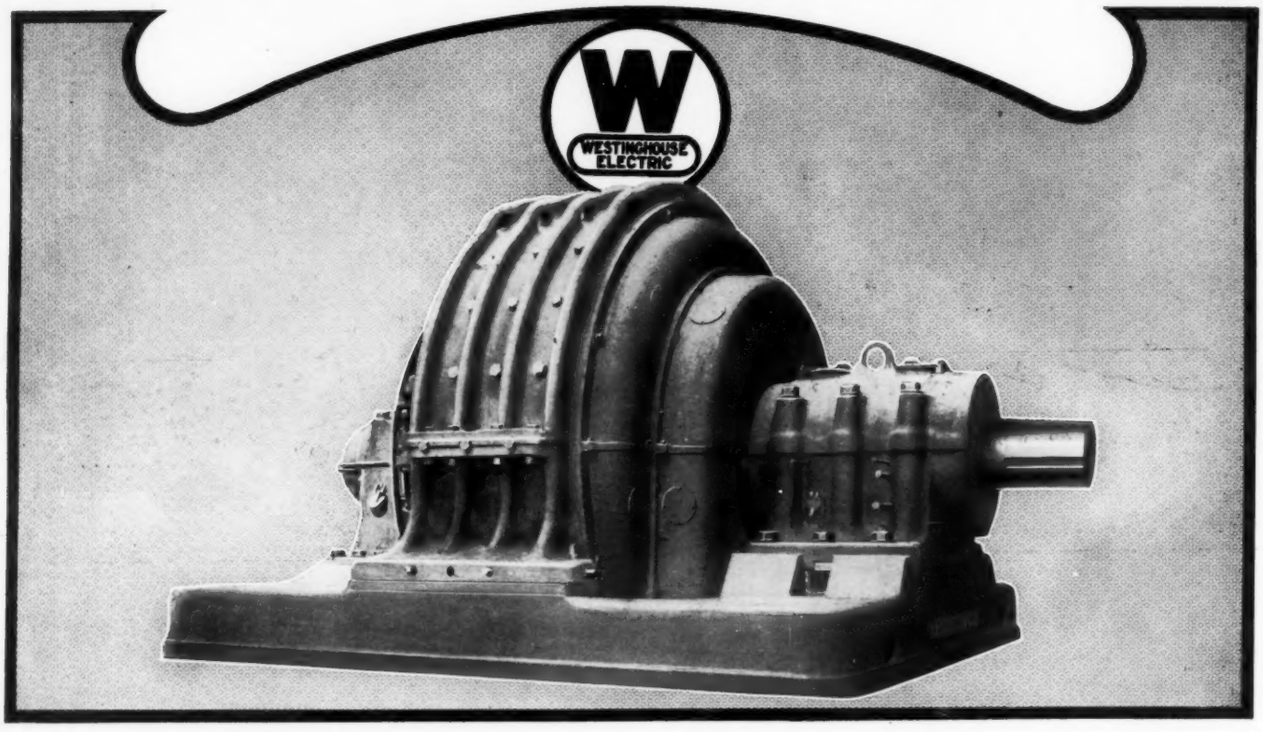
Birmingham, Ala.

Discussion on Mechanical and Electrical Analyses of 40-Inch Blooming Mill Screwdown

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# IRON AND STEEL ENGINEER

J. F. KELLY, Editor

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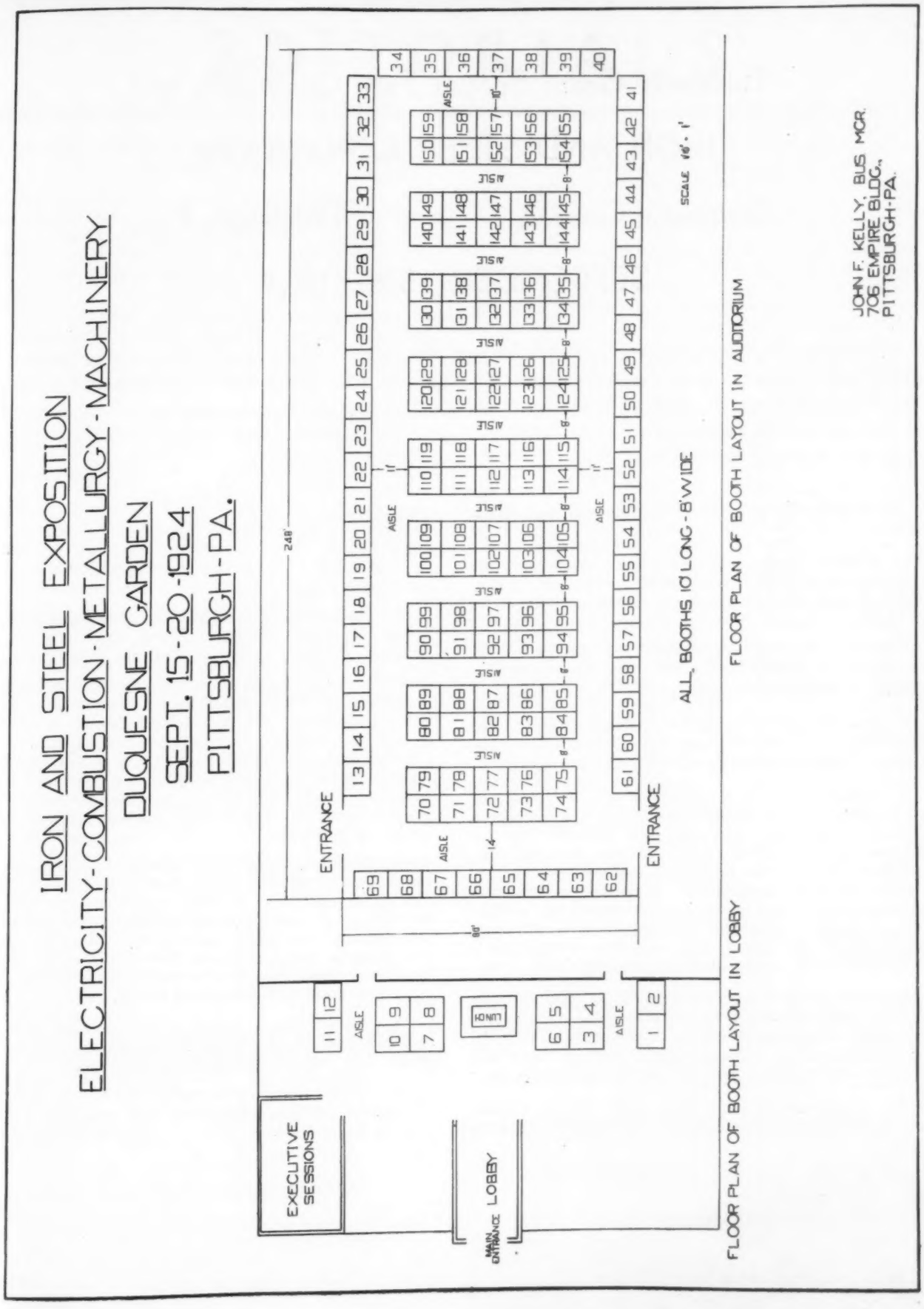
IRON AND STEEL EXPOSITION
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## Duquesne Garden - - Pittsburgh, Pa.

## SEPTEMBER 15-20, 1924

A reduction to one and one-half fare on the "Certificate Plan" will apply for members attending the Convention of the Association of Iron and Steel Electrical Engineers and Iron and Steel Exposition, to be held at Duquesne Garden, Pittsburgh, Pa., September 15-20, 1924, and also for dependent members of their families. This arrangement will apply from the Central Passenger Association territory.

The following directions are submitted for your guidance:

1. Tickets at the regular one-way tariff fare for the going journey may be obtained on any one of the following dates (but not on any other date): September 11-17.

Be sure that, when purchasing your going ticket, you request a CERTIFICATE. **Do not make the mistake of asking for a "receipt."**

2. Present yourself at the railroad station for ticket and certificate at least 30 minutes before departure of train on which you will begin your journey.

3. Certificates are not kept at all stations. If you inquire at your home station, you can ascertain whether certificates and through tickets can be obtained to place of meeting. If not obtainable at your home station, the agent will inform you at what station they can be obtained. You can in such case purchase local ticket to the station which has certificates in stock, where you can purchase a through ticket and at the same time ask for and obtain a CERTIFICATE to the place of meeting.

4. Immediately on your arrival at the meeting present your certificate to the endorsing officer, Mr. J. F. Kelly, Business Manager, as the reduced fare for the return journey will not apply unless your are properly identified as provided for by the certificate.

5. Arrangements have been made for the validation of certificates by a Special Agent of the carriers on September 15-20 if the required minimum of 250 certificates is presented.

6. **No refund of fare will be made on account of failure to either obtain a proper certificate nor on account of failure to have certificate validated.**

7. So as to prevent disappointment, it must be understood that the reduction on the return journey is not guaranteed, but is contingent on an attendance of not less than 250 members of the organization at the meeting and dependent members of their families, holding regularly issued certificates obtained from ticket agents at starting points, showing payment of regular one-way tariff fare of not less than 67 cents on going journey.

8. If the necessary minimum of 250 certificates is presented to the Special Agent as above explained, and your certificate is duly validated, you will be entitled up to and including September 24, 1924, to a return ticket via the same route over which you made the going journey, at one-half of the regular one-way tariff fare from the place of the meeting to the point at which your certificate was issued.

9. Return ticket issued at the reduced fare will not be good on any limited train on which such reduced fare transportation is not honored.

10. Tickets will be validated at the lobby of Duquesne Garden, where the Iron and Steel Exposition is being held.

# EDITORIALS

## ELECTRIC DRIVEN REVERSING BLOOMING MILL MOTORS

STEEL mill presidents, mill superintendents, engineering departments are always ready to listen and read about the improvements in methods of rolling steel, particularly if these methods tend to increase production with a corresponding reduction in cost.

Every so often the electrical manufacturers call upon the steel industry with a message describing the latest improvements made in electric drives, and the same we might say applies to the builders of steam engines.

In the last five years the builders of steam engines have been able to convince a number of steel companies that the initial cost of a motor installation was not justified in their particular case, and so far one steel company has furnished figures for the engineering fraternity's inspection (which may be found in this issue), which are calculated to substantiate the arguments advanced by the builders of steam engines at the time of purchase.

Your attention is solicited to the figures presented. They are the results obtained after a very careful series of tests and actual performance records.

We have yet to hear of the performances of the steam drives installed at the other steel companies, but no doubt, we will receive this data just as soon as the engines have been operating long enough to determine actual costs.

Notwithstanding the claims that are made by the exponents of steam drives maintenance is still a large factor and, like in the olden days, it seems still the custom even on the so-called modern engines to completely overhaul them each week-end. So much for the steam engines.

In the past five years 18 electric reversing sets have been installed, seven of which have replaced steam engines.

One of the outstanding features in the electric drive is the fact that you are able to determine your energy costs hourly. It is not necessary to make any unusual arrangements for tests, nor is there any necessity for guess work. You have your rolling costs always before you.

Experience has proven that the electric drive is more reliable, more flexible, easier to operate, capable of rolling larger tonnages, has less maintenance, less delays, less waste than any other form of drive.

The tendency and the trend of the times are for "more electric drives".

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## THE VALUE OF EXPOSITIONS

EACH year engineering societies, trade organizations, and private enterprises conduct expositions for the purpose of education. Very few of the expositions are conducted for profit. Most of them are operated at a loss.

Engineering societies are exceptionally fortunate in their expositions due primarily to the many opportunities which are presented to both the manufacturer and the engineer, to meet on a common ground, for the purpose of exchanging ideas.

In exchanging ideas, which should properly be termed "experiences" confidences are set up which result in better understandings of what the manufacturer has in mind, as to how he expects a piece of apparatus to function — and the engineer relates his experiences with the apparatus which are secured in the field of operation, thereby to a large degree, expediting the improvements of the arts in general.

However, some engineers, and fortunately they are few, do not derive the benefits which an exposition presents. For argument sake where, under one roof has any engineer the opportunity to personally examine and inspect as much diversified equipment as he is able to see in, not only our exposition, but any exposition. It is a well known fact that engineers (and fortunately again they are few), have spent their company's money traveling about the country for inspection purposes, when they have passed up the opportunity to attend engineering expositions right at their door. Consistency here is indeed a jewel.

Some manufacturers also lose sight of the main object in an exposition. The manufacturer who simply provides a rest room as his exhibit, is losing a lot of valuable time. What is the use, what benefit can be derived from the show if he does not surround himself and his salesmen with tangible evidence of what he produces for the criticisms and suggestions of engineers.

Expositions are not, and should not be regarded as social functions.

The Iron and Steel Exposition this year will offer to the engineer an opportunity to witness one of the greatest engineering exhibits ever held in America. It has to do with apparatus used in steel mills. It is not the largest exhibit in America. It is, however, the highest specialized practical demonstration in these United States.

No industry can boast of anything of its kind, which will approach in magnitude the Iron and Steel Exposition to be held at Duquesne Garden, September 15-20, 1924.

Iron and Steel Exposition
September 15-20, 1924
Duquesne Garden
Pittsburgh, Pa.

# Nineteenth Annual Convention A. I. & S. E. E.
# September 15-20, 1924
# Pittsburgh, Pa.

## HEADQUARTERS—WM. PENN HOTEL

Make your reservations at once. Do not delay. Hotel will be crowded. Mention A. I. & S. E. E. Convention when applying for reservations.

## IRON AND STEEL EXPOSITION—DUQUESNE GARDEN

The September issue of The Iron and Steel Engineer will contain the complete story of the Iron and Steel Exposition.

## TRANSPORTATION

In this issue, on Page 412, you will find instructions with respect to the concessions granted in connection with those who attend the Convention and Exposition. Read the rules carefully so you will be able to have your ticket properly validated.

## INFORMATION AND REGISTRATION

**Lobby, Wm. Penn Hotel**

Mr. George H. Schaeffer, Chairman of the Information and Registration Committee, will have headquarters in the lobby of the Wm. Penn Hotel. As soon as you arrive look up the chairman and register.

## TECHNICAL SESSIONS

All the Technical Sessions will be held at Duquesne Garden. Technical Sessions will commence Tuesday morning at 9:30, and each morning thereafter, until close of the Convention. There will be no afternoon sessions.

## BUSINESS SESSION

Monday morning, 10 o'clock. The Business Session will be held in the Blue Room, seventeenth floor, Wm. Penn Hotel.

## GENERAL ARRANGEMENTS

Mr. A. C. Cummins, Chairman. All arrangements in connection with the Convention will be taken care of by Mr. Cummins and his committee. As soon as you have registered Mr. Cummins and his committee will be on hand to take care of you.

## BANQUET COMMITTEE

Mr. A. J. Standing, Chairman. All arrangements and all details in connection with the nineteenth Annual Banquet will be handled by this committee. As soon as you arrive at the Convention make an effort to notify this committee just how many reservations you desire. Remember those applying first will receive the most favorable seating arrangements.

## INSPECTION TRIPS

Mr. James Farrington, Chairman. Quite a number of industrials and also central stations will open their plants to the members and visitors at this Convention. Complete details will be furnished you when you arrive at the Convention.

# ELECTRIC HEATING FURNACE DAY

## Wednesday, September 17, 1924

## Duquesne Garden, - - Pittsburgh, Pa.

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### DISCUSSIONS COVERING

Low Medium High
Temperature Furnaces.

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### PAPERS WILL COVER

Soderberg Electrode
Electrode Regulator
Charging Machines
Multiple Melting Furnace
Regenerator Car Type Furnace
Coulter-Flow Regenerator Car Type Furnace
Double End Car Type Furnace
Rotary Type Furnace
Continuous Conveyor Furnace
Box Type Electric Furnace
Vitreous Enameling Furnaces
Comparison Between Furnaces Using Oil and Electric Energy
Muffle Type Furnace
Heat Treating Furnaces
Bench Type and Floor Mounted Furnace of the Hearth Type
Tool Treating Furnaces
Tool Steel Tempering Furnaces
Furnaces for Annealing Castings
Continuous Hardening Electric Furnaces
Low Temperature Ovens
Furnaces for Baking Motor Armatures
Furnaces for Enameling
Electric Steam Boilers
Electric Sheet Mill Roll Heaters

Industry in general is invited to send its engineering representatives to this meeting and all other technical sessions to be held during the week of September 15th to 20th, at Duquesne Garden, Pittsburgh, Pa.

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# Electrically Driven Reversing Mills

By J. D. WRIGHT*, R. W. DAVIS† and O. H. NEEDHAM‡

THE first electrically-driven reversing mill equipment constructed in this country was installed in 1906 to drive a 30-in. reversing universal plate mill. It is of interest to note that this installation was made only one year after the first application of any large rolling mill motor of any type. Up to the present time, 57 American-built equipments totalling 213,550 hp., continuous rating, have been constructed. Six of these have been purchased by Canadian firms and nine by foreign steel companies. The field of application now includes blooming, slabbing, universal plate, sheared plate, universal skelp, rail, structural, sheet bar, billet, copper and brass mills, and one drive for a shear intensifier. Seven of the 57 equipments, totalling 35,950 hp., have been built to replace other types of drives on blooming, rail, universal plate and universal skelp mills.

From all these installations a large amount of operating data have been obtained so that the selection of proper equipment for a given mill can readily be made. The factors which determine the size of driving motor are as follows:

1. Tonnage to be rolled.
2. Elongation (ratio of original to final length).
3. Rolling schedule (number of passes and reduction per pass).
4. Diameter of rolls.
5. Temperature of metal.

Both the continuous capacity and the peak load or maximum torque capacity must be determined, as either may be the factor which fixes the motor size. The continuous capacity is affected by all the factors just given while the maximum torque which the motor must exert is affected by the last three. The continuous capacity is proportional both to the tonnage and the elongation so that for a given tonnage rate it is always necessary to know the elongation and for a given elongation it is always necessary to know the tonnage. An important point in connection with the tonnage rate which must always be borne in mind when figuring motor capacities is that in order to produce the desired average monthly tonnage, the motor must be capable of rolling for several hours at a rate considerably above this average, in order to produce the record runs which go to make up the total output. The one-hour record production is even higher but as it is usually followed by an hour slightly under the average, it may quite safely be assumed that if the motor has ample capacity to handle a record 8-hour turn it will be capable of handling an intensive one-hour production.

It sometimes happens that the work proposed for a given mill may not be equal to the output which experience has shown can be obtained with a mill of that type and size. In such cases serious consideration should be given to the selection of a motor which will drive the mill at its capacity rather than one which will meet the proposed conditions. As soon as it is found that a greater output can be secured than was originally expected, the tendency will be to push production to the limit of the mill capacity. While an undersized reversing equipment would probably drive the mill to the limit of its capacity, after a time serious trouble might result from overheating.

The maximum torque capacity is proportional to the draft and roll diameter and is affected by the temperature of the metal as shown by Fig. 1. The rolling schedule should be analyzed to determine the maximum torque which the motor is required to develop at various speeds. In general, it may be said that the physical size of the motor is determined by the maximum torque which it must exert independent of the speed at which this torque is required but the physical size of the generator which supplies power to the motor is affected directly by the motor speed at which the maximum torque occurs.

POWER CURVE
Showing increase in power to roll steel with decrease in temperature

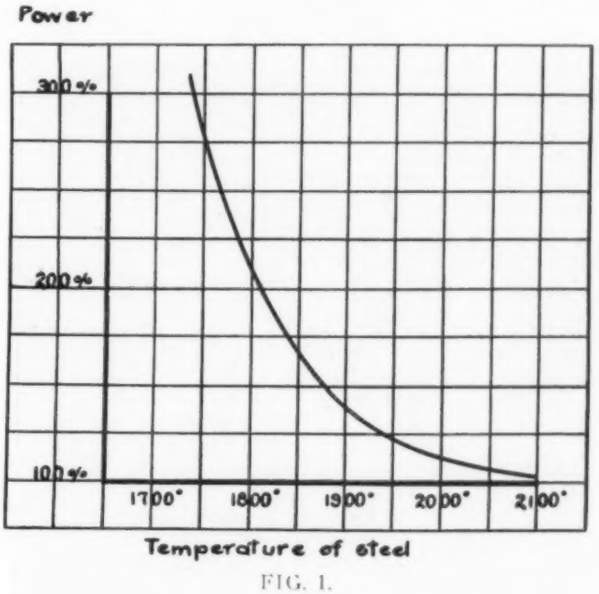


FIG. 1.

The rolling schedules on the majority of reversing mills are such that the maximum torques usually occur among the earlier passes. It is, therefore, possible to use a motor with relatively low full field speed and obtain the higher speeds by weakening the motor field.

The size of motor may be fixed either by the heating effect of the load or by the maximum torque.

In Fig. 2 are plotted the torques and speeds for the various passes of a typical blooming mill. From an inspection of these data it is evident that a motor

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†Electrical Engineer, Allis Chalmers Manufacturing Company, Milwaukee, Wis.

‡Electrical Engineer, Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa.

Presented at Pittsburgh Monthly Meeting, May 10, 1924.

having a speed torque curve shown by the full line "B" will be able to meet the rolling schedule satisfactorily from the standpoint of torque. The root mean square or heating effect of the load must then be calculated to determine the continuous capacity, which for this rolling schedule is Curve A. A sufficient margin in torque capacity above Curve B must be available for some unusual or unforeseen operating condition.

Curve C represents the emergency or circuit breaker setting. The speed hp. curves corresponding to the speed torque curves are also shown by the dotted lines in Fig. 2.

The Ilgner Ward Leonard system of control is now universally used for reversing mills. Fig. 3 shows schematically the diagram of connections for a single unit equipment. Power for the d.c. roll motor is obtained from a flywheel set consisting of a slip ring induction motor, flywheel and d.c. generator. The armatures of the motor and generator are connected by means of heavy copper buses through a high capacity circuit breaker. The fields of the generator and motor are separately excited from a motor-driven exciter. Speed control of the roll motor from

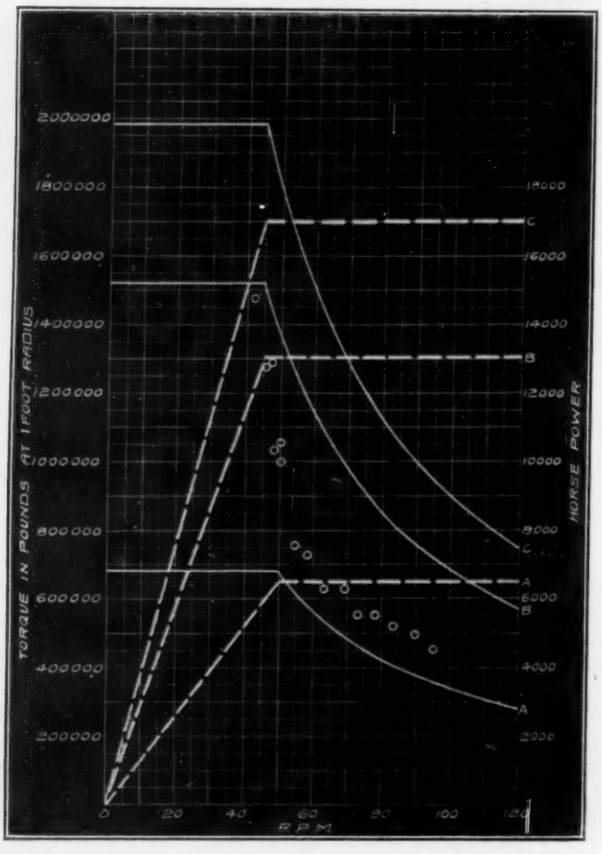


FIG. 2

zero to full field speed is obtained by varying the voltage supplied to the armature by control of the field strength of the d.c. generator. Higher speeds are obtained by weakening the motor field. To reverse the motor the generator field is reversed.

The generators are always shunt wound but both shunt and compound wound roll motors have been used. In the latter case the compounding is obtained indirectly by means of a small series exciter and a separate winding on the main poles of the reversing motor.

Due to the very high currents encountered in the main circuit, it would be extremely difficult to reverse the ordinary type of series field which would be necessary to keep the proper shunt and series-field relation. Therefore, the series exciter and the separate field winding are used, the field of the series exciter being connected in series with the main motor armature circuit and the armature of the series exciter being connected across the separate winding of the main reversing motor as shown in Fig. 4. The switches for reversing this field are operated from the master switch which also operates the reversing switches in the field of the generator. By this scheme the compounding effect is obtained without the necessity of reversing the heavy armature current. All adjustments of the field circuits of the generator and motor are made by magnetically operated switches or contactors controlled from the operator's master switch which is located in the mill. The rate of acceleration and retardation can easily be adjusted to suit the best conditions of operation. The inherent characteristics of the field circuits and the design of the automatic features of the control are such that the operation of the motor in accelerating, retarding and during the pass is practically automatic. Instant response of the motor to movement of the controller handle is at all times available to the operator so that if trouble in rolling develops during a pass, he can immediately change the speed or reverse the mill.

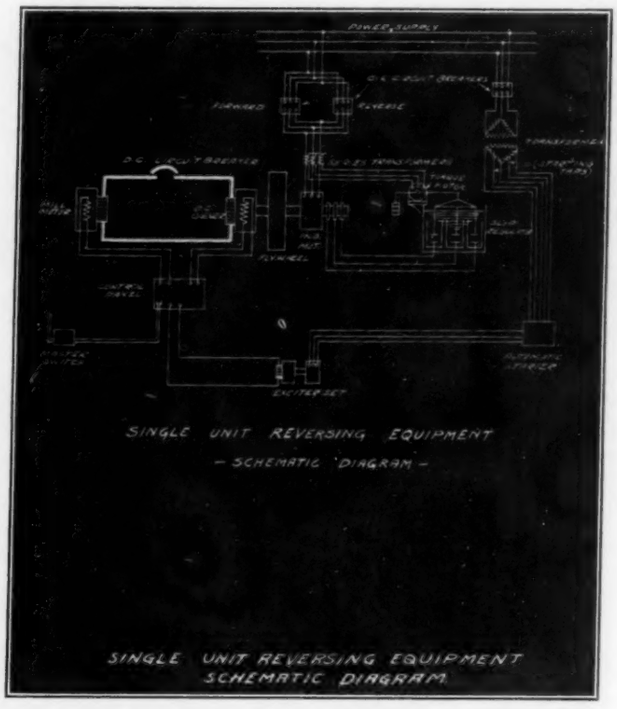


FIG. 3.

The usual practice for normal passes is for the motor operator to keep the motor revolving slowly until the metal enters the rolls and then throw the master switch to the maximum speed which can be reached as determined by the setting of the current limit relay. When the operator throws the master

switch to the opposite side at the end of the pass to reverse the motor, the reversal takes place at a predetermined rate and is not determined by the temperament of the operator. On account of these characteristics of operation, each acceleration and reversal is accomplished in the most efficient manner and change of operators will have little or no effect on the efficiency of operation.

The direction in which the master switch is operated determines the direction of rotation and the position to which it is moved determines the speed of the reversing motor. There is no material slowing down of the motor on entering the steel and no racing after the steel leaves the rolls, for the motor speed is practically constant for a given position of the masterswitch handle.

It is standard practice to use forced ventilation for the motor to insure a continuous flow of air through the windings regardless of the speed or direction of rotation. Due to the low average speed on the motor, it does not lend itself readily to self

**Double Unit Reversing Equipment**

SCHEMATIC DIAGRAM

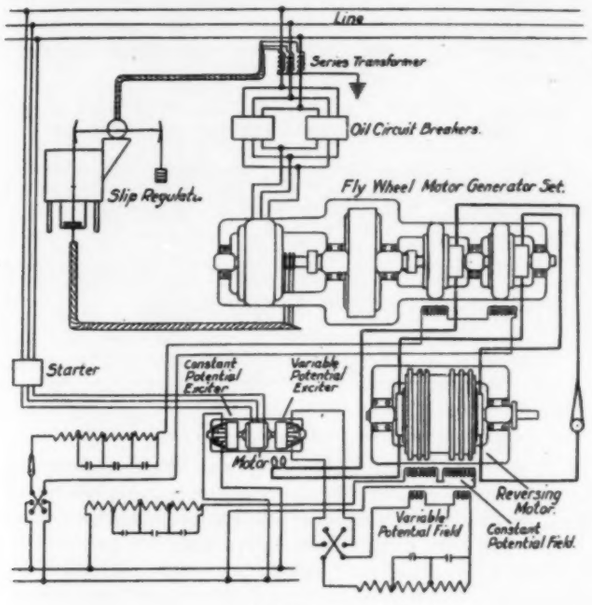


FIG. 4.

ventilation. The use of air cleaning apparatus reduces to a minimum the amount of mill dust which finds its way into the motor windings and motor room. Motors are rated in continuous hp. at full field speed based on 50 deg. C. temperature rise with proper volume of air supplied to the windings.

All mechanical parts are designed to withstand the heavy strains which the mill loads impose. Heavy pedestals, large bearings, large diameter shafts, heavy frames and heavy bedplates are characteristic of reversing motors for all applications. See Figs. 5 and 6.

The electrical design of the generators must be such that they will carry the same peak loads as the reversing motor, so commutating and compensating windings are used in the fields. Since the generators operate continuously at practically constant speed, self ventilation is satisfactory. The kilowatt rating is based on normal voltage, at rated speed with temperature rise of 50 deg. C.

The electrical features of the induction motor driving the flywheel set are similar to those of any standard induction motor of the same rating suitable for steel mill service. Self ventilation is satisfactory

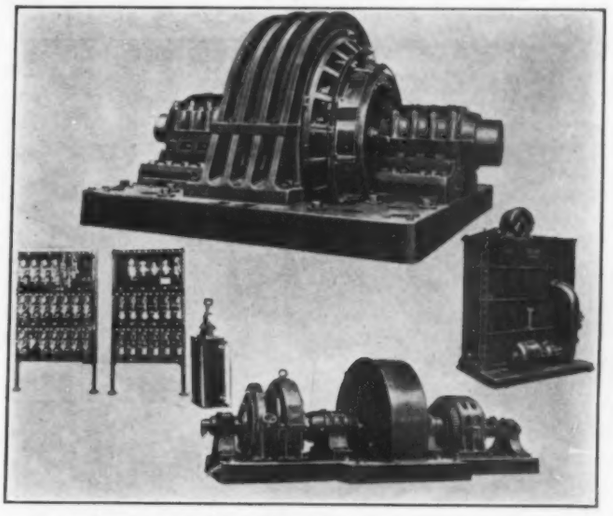

FIG. 5.

for this machine. 50 deg. C. temperature rise is considered standard. See Fig. 7.

The mechanical parts of the flywheel motor-generator set are similar to those of a standard motor generator set except that bearings, shafts and bedplates are proportioned to carry the increased weight of the rotating parts. All bearings are designed for ring oiling with provision for gravity feed. Large flywheel bearings are water cooled.

It is the function of the flywheel to deliver energy to the generators during periods of high demand in order to prevent these peaks reaching the incoming power lines. A flywheel is a means of storing energy and this energy can be given up only by allowing the speed of the wheel to decrease. During periods of

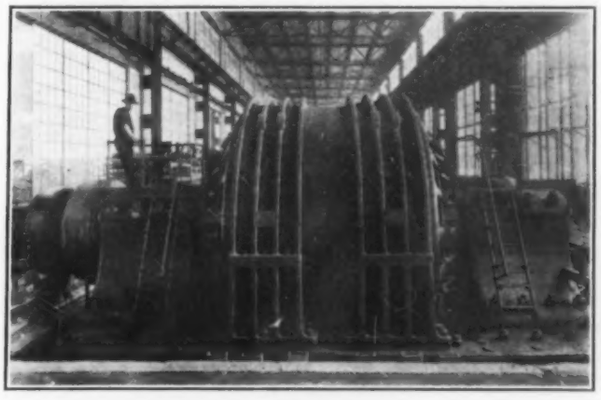

FIG. 6.

light load on the generator the flywheel speed is increased and energy stored. As a result of this continual storage in and discharge of energy from the flywheel, it is possible to limit the induction motor loads so that the peaks are not much higher than the average load. For practical reasons and because

of the lack of uniformity of the rolling cycle, the input to the induction motor of a reversing mill equipment is somewhat irregular although the maximum input can be very definitely limited. Fig. 8 is a reproduction of a typical graphic wattmeter record showing the input to the induction motor of a reversing blooming mill equipment. During the roll-

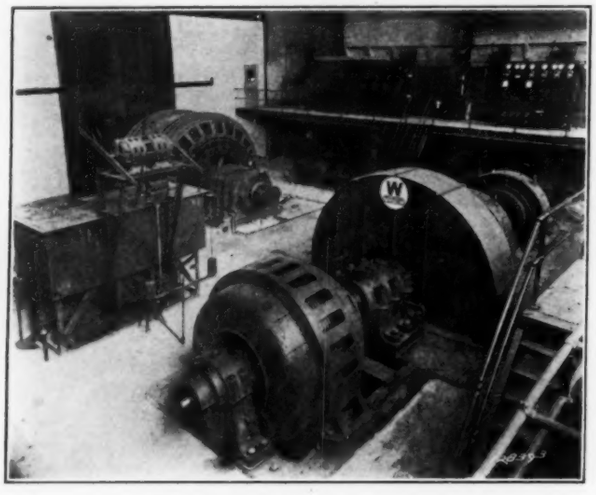

FIG. 7.

ing process the input varies from friction load to a maximum of 3000 kw. There is a constant interchange of energy between the generators, flywheel and motor. The load fluctuations on the induction motor are not rapid, however, so it is by no means an undesirable power plant load. A typical high speed graphic record showing the power input during the rolling of a single ingot in a blooming mill is shown in Fig. 9.

The limitation of the input to the induction motor is obtained by means of a liquid slip regulator. It is the function of the latter to so adjust the resistance in the slip ring circuit of the induction motor that, during periods of heavy loads, the speed of the set is decreased and the flywheel allowed to give up its energy, and during periods of light load the speed

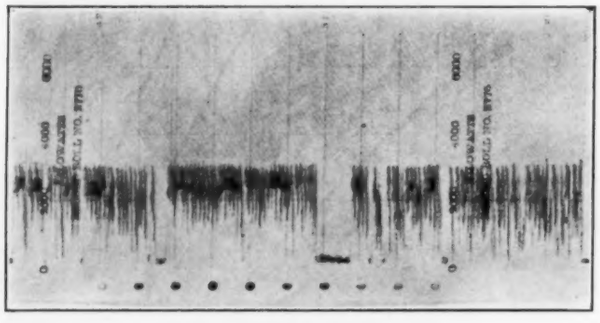

FIG. 8

of the set is increased and energy is stored in the flywheel. The slip regulator is also used for starting the flywheel set, which operation it also performs automatically after the motor primary oil circuit breaker is closed.

The types of slip regulators used may be divided into two classes:

1. Those with stationary electrodes.
2. Those with movable electrodes.

In slip regulators of the first type, the slip ring leads are connected to three stationary electrodes. The necessary variation of resistance in the induction motor secondary circuit is obtained by adjustment of the position of the movable electrodes. This adjustment is obtained by a torque motor which derives its power from series transformers located in the lines leading to the primary circuit of the induction motor on the flywheel set. When the current taken by the induction motor tends to exceed the amount for which the regulator is set, the torque of the motor overcomes the weight of the movable electrodes and pulls them away from the stationary electrodes. This introduces resistance in the secondary circuit of the induction motor, causing it to slow down. When the current taken by the induction motor falls below the setting of the regulator, the weight of the movable electrodes exceeds the torque of the motor and the secondary resistance is decreased and the speed of the flywheel set is raised. Before the set can be started, the maximum separation of stationary and movable electrodes must exist, thereby having in circuit the maximum resistance. The acceleration from rest to full speed is entirely automatic as the torque motor limits the power input to the value at which the regulator is set.

In slip regulators of the second type the adjustment of the secondary resistance is obtained by con-

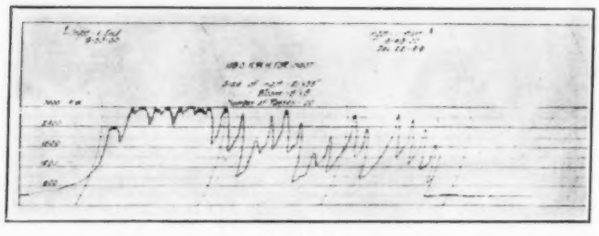

FIG. 9

trol of the level of the electrolyte in the tank in which the stationary electrodes are suspended. This adjustment is also obtained by means of a torque motor which operates adjustable weirs and by means of a continuously running motor-driven pump which pumps the electrolyte from a lower tank into the tank containing the electrodes. The level of electrolyte is lowered to increase the resistance and raised to decrease the resistance. When the set is started, the electrolyte is at its lowest level. After the primary oil circuit breaker is closed, the circulating pump motor is started which causes the electrolyte level to rise. The induction motor is thus automatically brought up to speed.

Provision is always made for plugging the induction motor so that the flywheel set may quickly be brought to rest. If allowed to coast, the time required for the flywheel set to stop would be more than an hour, where as by plugging, it can be stopped in about one minute.

The capacity of the induction motor driving the flywheel set is determined by the tonnage and elongation of the steel to be rolled and by the extent to which the flywheel helps out on peak loads. If the induction motor carried only the average load, the power input would be practically constant at a value

equal to the tonnage per hour multiplied by the kw. hr. per ton. However, as pointed out earlier, this condition is not realized in reversing mill practice. The setting of the slip regulator is usually about 15 to 20 per cent higher than the maximum integrated load per hour. That is the ratio of maximum kw. hrs. consumed

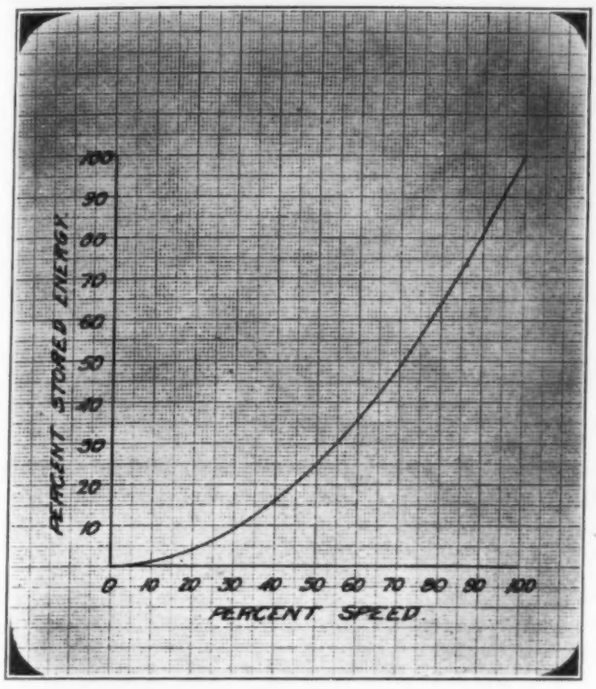


FIG. 10.

per hour to the kw. setting of the slip regulators will be found to be approximately 85 per cent.

The selection of size of flywheel is determined by the amount and duration of loads imposed on the generators and the maximum input to the induction motor. It is usual practice to provide sufficient stored energy in the wheel so that its speed does not drop more than approximately 15 per cent. There are three reasons for this — namely, maintenance of generator voltage, limitation of slip regulator losses and efficient utilization of flywheel energy. With a 15 per cent drop in speed a wheel will deliver 28 per cent of its total stored energy. The relation between speed and stored energy is shown in Fig. 10.

The losses occurring in an electric reversing drive can be grouped under two general headings: Rolling and Fixed Losses. The stand-by losses are very small or nil depending upon whether power is generated within the plant or purchased.

The losses in an electric drive are not increased by use. After the equipment has been in constant use for 10 or 15 years they will be practically the same as when first installed.

The separation of the rolling losses into those which are a function of the displacement of the metal between the rolls and those which are involved in the reversing of the motor armature will give a clear understanding of the operation of an equipment of this kind. Those which are dependent upon the work done on the metal are the windage, friction, iron, field, armature and brush losses of the reversing motor; the iron, field, armature, copper and brush losses of the generator and the copper losses of the induction motor.

The armature resistance and brush losses make up the greater part of the losses which are dependent upon the load. The iron, friction, and windage losses are determined by the speed of the reversing motor. The field losses are practically constant while the motor is in operation. Therefore, the rolling losses are practically proportional to the R.M.S. value of the current.

The reversing of the mill motor armature imposes considerable load on the equipment. A portion of this load is a dead loss similar to that itemized above.

Due to the inherent characteristics of the Ward-Leonard control, a large part of the energy stored in the motor armature is regained during each reversal.

Fig. 11 is an oscillogram which shows the relations of changes in armature current, voltage and speed in respect to time during a reversal. At the instant the master is moved from the forward to the reverse position the motor begins to function as a generator, as shown by the reversal of the current. This generator action is maintained until the speed reaches zero. At that instant motor action starts and the motor accelerates in the reverse direction. The rapid reversal of the armature with its large interchange of energy is accomplished without the least disturbance as is shown by the smoothness of the current and speed curves. The losses incurred by this interchange of energy are the armature resistance, brush, field and iron losses of the motor and generator and the windage and friction losses of the reversing motor. Tests show that from 60 per cent to 70 per cent of the energy stored in the motor armature is saved when pumping back into the flywheel set with the mill

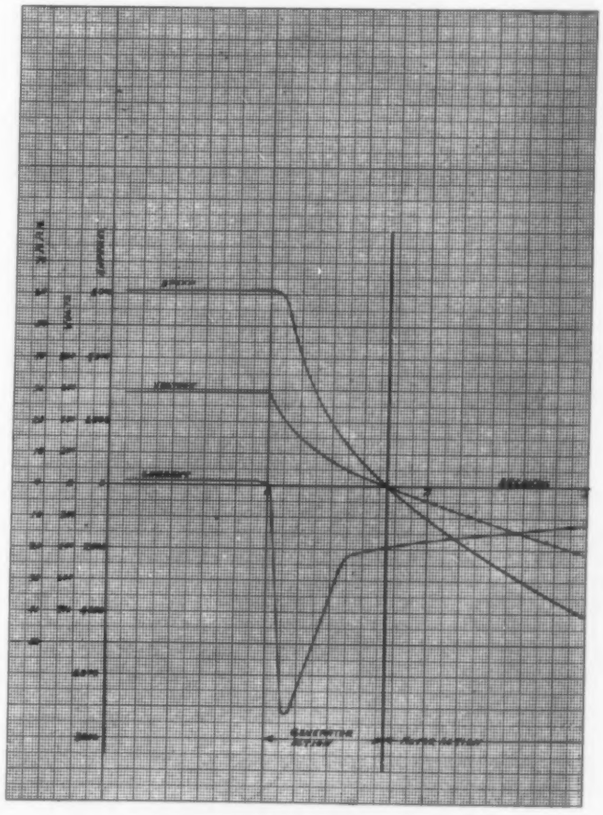

FIG. 11.

empty. If the mill be slowed down while the piece is in the rolls the percentage of stored energy saved is even greater, for in this instance a considerable portion of the stored energy in the armature is directly expended in elongating the metal.

The torque required to accelerate the armature of a twin unit machine having a $WR^2$ of 3,300,000 from 0-90 Rpm. in 1.8 seconds, as shown in the previous figure, is obtained by applying the following formula:

$$T = 3.25\ WR^2 \frac{V}{t}\ 10^{-3}$$

Where

T = lbs. torque at 1 foot radius
V = final velocity in Rpm.
t = seconds required to obtain final velocity.

$$T = 3.25 \times 3{,}300{,}000 \times \frac{90}{1.8} \times 10^{-3}$$

$$= 535{,}000$$

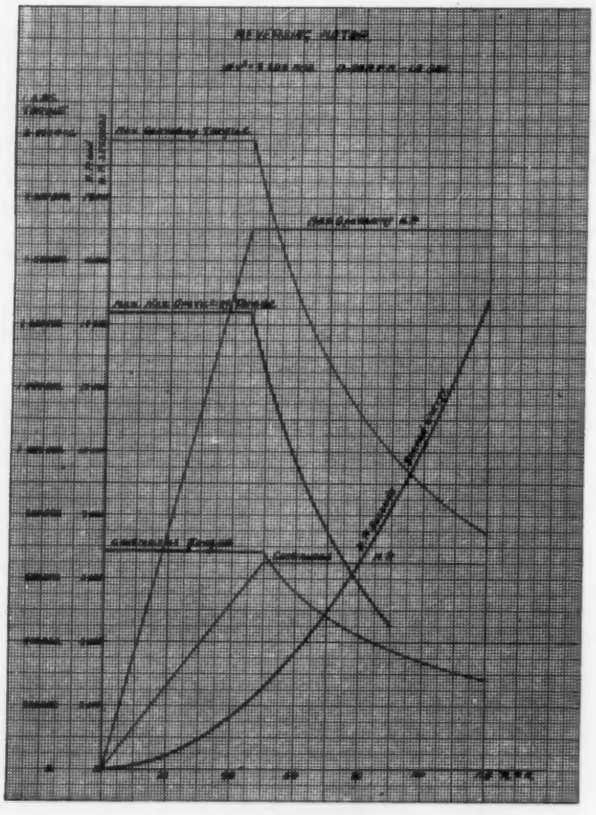

FIG. 12.

Since it is common practice to accelerate with a piece in the mill, the torque required to accelerate the armature must be subtracted from the maximum operating torque of the motor to obtain the net torque that is available for displacing the metal.

The energy stored in the armature can be determined by applying the formula:

$E$ = $WR^2 \times N^2 \times .000000311$
$E$ = stored energy in hp. sec.
$N$ = revolutions per minute.

$$E = 3{,}300{,}000 \times \frac{90^2}{} \times .000000311 \doteq 8310 \text{ hp. sec.}$$

Fig. 12 shows the reversing motor curves previously shown, with the maximum net operating torque and stored energy curves added.

The fixed losses of an equipment of this kind are the windage and friction of the set, core loss of the induction motor, and the copper loss in the induction motor due to the idle current. Since the speed of

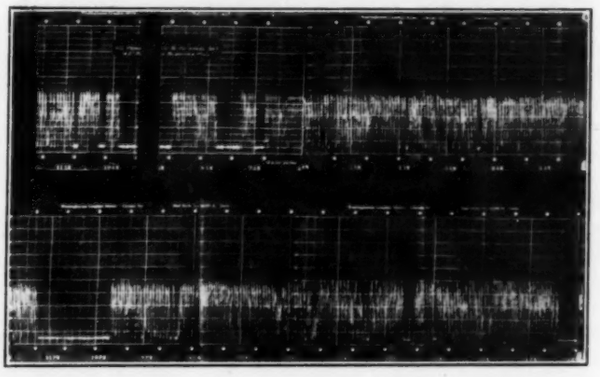

FIG. 13

the fly wheel motor generator varies within comparatively small limits, these losses are practically constant. The fixed losses of a twin unit equipment on a 40-in. bloomer are approximately 250 kw. Fig. 13 was taken shortly after the mill was installed and Fig. 14 after it had been in operation about two years. It will be noted that the idle loss is approximately the same in both curves.

The fixed losses on a single unit driving a 35-in. mill are approximately 160 kw.

In addition to these fixed losses of the fly wheel motor generator, there are the losses representing the power input to the exciter set, blower and air conditioning equipment. This power requirement is constant and is only a very small percentage of the input of the entire equipment.

Fig. 15 shows the plant load of a steel mill generating station with a reversing mill drive in operation.

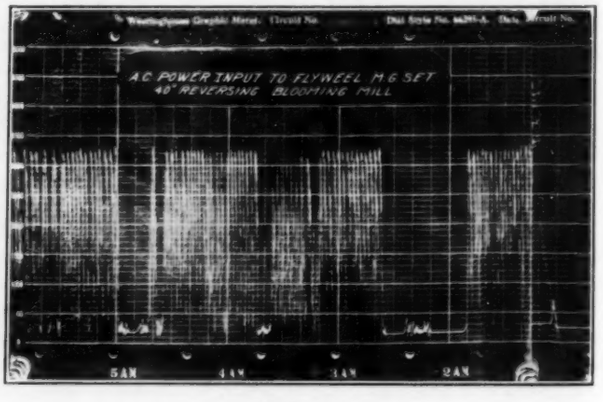


FIG. 14.

It will be noted that the bloomer does not impose any high peak loads.

The absence of stand-by losses in a reversing mill drive is a very important item. While the mill is in production it can be operated at its most economical rate for such a period as is necessary to fill the order. The mill can then be shut down until another order

is available. All losses cease the instant the main line switch is opened and the set shut down. With the purchased power there are absolutely no stand-by losses. There is a further saving where the mill is shut down during the night or over week-ends in that

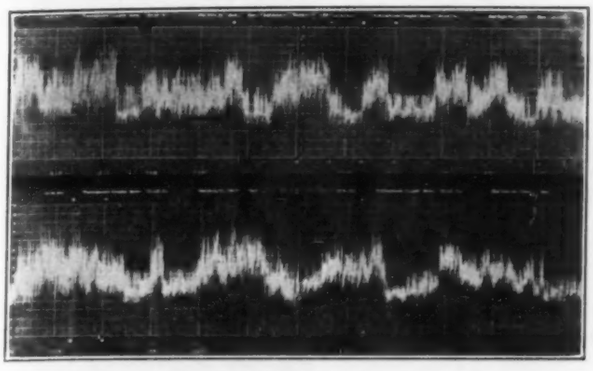

FIG. 15.

no attendant is necessary while the equipment is down. The motor room is just locked up and every one can go home.

The cost of generating power for a manufactured product has always included in it, as one of the basic items, the cost of fuel supplied in the power generating

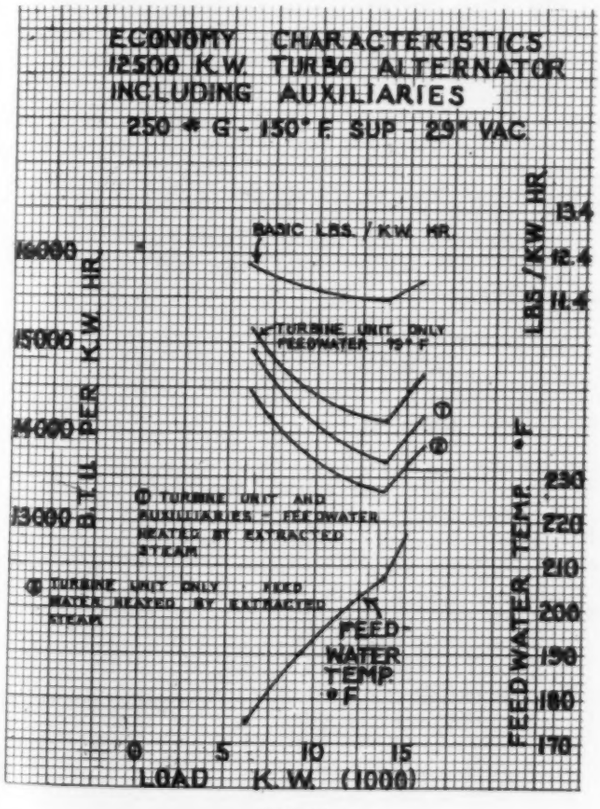
ECONOMY CHARACTERISTICS
12500 K.W. TURBO ALTERNATOR
INCLUDING AUXILIARIES
250 # G - 150° F. SUP - 29" VAC.
BASIC LBS. / KW. HR.
TURBINE UNIT ONLY FEEDWATER 75° F
① TURBINE UNIT AND AUXILIARIES - FEEDWATER HEATED BY EXTRACTED STEAM
② TURBINE UNIT ONLY FEED WATER HEATED BY EXTRACTED STEAM
FEED WATER TEMP. °F
B.T.U. PER K.W. HR.
LBS. / K.W. HR.
FEED WATER TEMP. °F.
LOAD K.W. (1000)

FIG. 16

plant. However, in considering the processes which make up the total cost of the manufactured product, the cost of power is frequently and improperly expressed in related terms which belong to and have found use in power plant engineering analysis.

The product of a power house, generating electricity, is stated in terms of kilowatt hours and the cost of this product is given customarily in cents per kwh. In analyzing the factors which make up the cost of power, delivered by a power generator station to the system, the product of the boiler room is given in pounds of steam per unit of time and the cost of the boiler room product is generally stated in cents per thousand pounds of steam.

It is obvious, from the foregoing, for different manufacturing processes employing electric power, the power consumption in terms of kwh. per ton of finished product will be an indirect measure of the cost of power for the process. If steam is used in the manufacturing process for purposes other than generating power, the pounds of steam per ton of finished product will also be an indirect measure of the cost of power.

For a steel rolling mill, with different methods of applying power through electric motors supplied from steam and gas prime movers and by steam en-

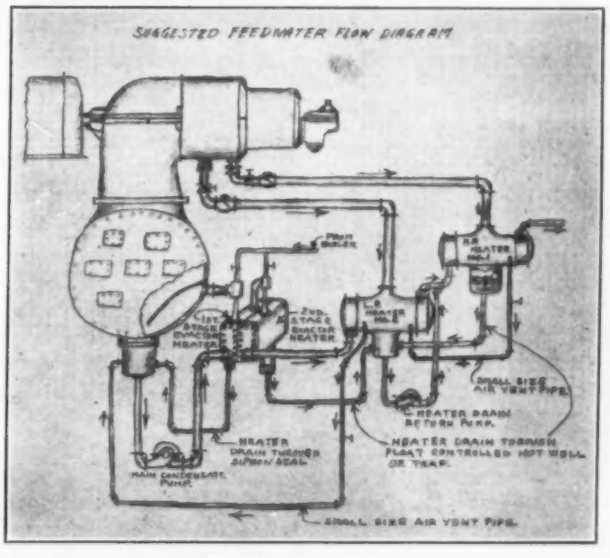


FIG. 17.

gines driving the rolls directly, the use of power plant units, such as kwh. per ton of steel and pounds of steam per ton of steel do not constitute a proper method for considering the cost of power in rolling mill work. In addition, the use of these units does not furnish a direct method of comparing the economy of the different arrangements. In all the methods of roll driving, the power supplied is originally obtained from the burning of fuel and the heat units contained in the fuel supplying the power generating equipment at its source, furnish beyond question the most suitable basis for expressing the power consumption of the rolling process.

The introduction of such a unit as the Btu. in the fuel supplied the power house per ton of steel, would have the same effect in rendering all data readily comparable in steel mill work as was had in power plant work following the adoption of the unit of economy of Btu. per kwh.

The older corresponding units in the power plant field were many, the principle ones being pounds of coal per kwh. and pounds of steam per kwh. Neither of these units were suitable for measuring and com-

paring power plant performance and their use frequently lead to wrong conclusions being reached as to the relative economy of different types of power and steam generating equipment and systems.

With a view to bringing out the effect of different factors on the cost of power for rolling, it has seemed

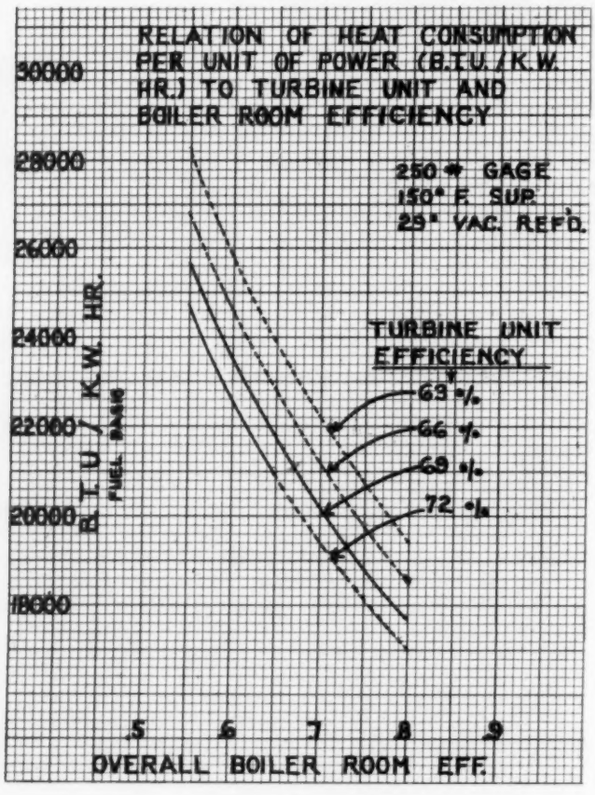


FIG. 18.

desirable to show graphically the heat consumption per kwh. for a modern 12500 kw. turbo generator operating with normal steam pressure and superheat. The typical steam conditions selected are 250 lb. gauge pressure at the turbine, 150 deg. F. superheat (corresponding to a total steam temperature of 556 deg. F.) and 29-in. vacuum. The typical unit selected has had its economy based on being proportioned for a rolling mill type of load involving heavy momentary overloads reaching a total of 16000 kw. The economy of the turbine has been taken as including the steam used for a steam jet type of air pump and the power required for the necessary exciter and condenser auxiliary pumping equipment. The turbine has been taken as being installed with two extraction type feedwater heaters combined with deaerating equipment and heaters condensing the steam from steam jet air pumps. The final economy of such a unit has been expressed in terms of the heat consumption in Btu. per kwh.

The following tabulated heat consumptions for turbine and condenser unit complete are based primarily on the heat consumptions of a turbo alternator set without charges for auxiliary equipment. It has been stated that the equipment included in the complete unit takes account of two extraction type of feedwater heaters in addition to the condenser auxiliaries mentioned and as a means of showing the basis of the estimates which follow, the economy characteristics of the turbo alternator unit alone have been summarized graphically on Fig. No. 16. This diagram shows the heat consumption of the turbo alternator when it is charged with all of the heat in the steam down to a condensate or feedwater temperature of 79 deg. F. corresponding to the temperature of water returned from the condenser and also the heat consumption when the feedwater is heated in extraction type of feedwater heaters to the final feedwater temperatures at different loads as shown graphically on the diagram. As a further comparison and as showing the basis of the estimates made, the heat consumption of the complete power house unit is plotted as a dotted line. It is to be borne in mind that the general heat consumption and other estimates which follow are all based on the performance of the turbo alternator, including the auxiliaries which have been listed.

The basis for the turbine unit including air pump and condenser auxiliaries is as follows:

*12,500-K.W., 60-Cycle Turbo-Alternator—250-Lb. Ga., 150 Deg. F. — 29-In. Vac.*

| Load | ½ | ¾ | Full | Momentary overload or continuous at 100% P.F. |
|---|---|---|---|---|
| Kilowatt | 6250 | 9375 | 12500 | 16000 |
| Final feedwater temp. deg. F. | 174 | 190 | 203 | 217 |
| Heat consumption including air pump and condenser auxiliaries Btu. per kwh. | 14920 | 14150 | 13780 | 14200 |

Referring to the matter of heating feedwater by means of steam extracted from the turbine, it is fairly well accepted now that this system, due to its greater

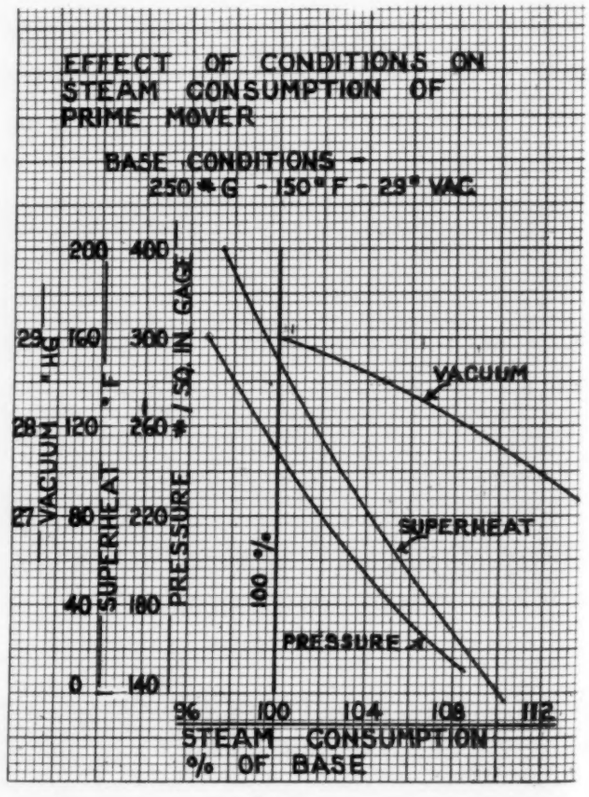


FIG. 19.

economy and automatic regulating features which insure a proper heat balance being maintained without dependence being placed on the skill or attentiveness of the operators, is preferable to the older scheme of using a house generating set or steam driven auxiliary equipment. Such feedwater heating arrangements are now practically universal for modern power plant in-

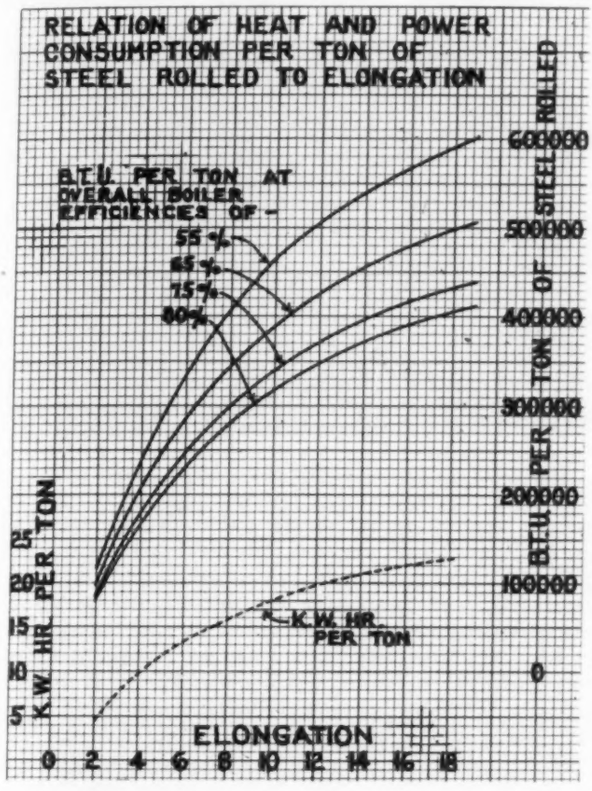


FIG. 20

stallations and the performance of a typical turbo alternator has, therefore, been based on the use of this efficient process.

As a matter of interest there is included, as Fig. No. 17, a feedwater flow sheet corresponding in general to that on which the estimates made have been based.

The average economy for the unit including auxiliaries has been taken by giving equal weight to all loads on the assumption that the constant power requirement would keep such a steel mill unit loaded up to approximately half load, the swinging load covering the range from one-half to the overload condition. As an approximation on this basis the average heat consumption of the unit has been taken as 14140 Btu. per kwh.

With the performance of the engine room prime mover fixed as in the foregoing, it is feasible to show the effect of boiler room conditions as reflected in the overall boiler room efficiency on the final heat consumption of the plant. This is shown graphically on attached to Fig. No. 18, which shows the Btu. per kwh. plotted as a function of the overall boiler room efficiency. Using the typical unit outlined in the preceding, which has an over-all efficiency based on the energy available to its turbine of 69 per cent the resulting curve is shown as a solid line. To show also on this diagram the effect of both engine room and boiler room efficiency on the heat consumption, additional lines (dotted) have been plotted for engine room units having efficiencies of 63 per cent, 66 per cent and 72 per cent.

It will be obvious from this diagram (No. 8) that if consideration is given only to the kwh. per ton of steel it will not be a suitable standard for judging the economy of the rolling process. In arriving at the cost of power, the efficiency of the power system is now universally expressed in Btu. per kwh. and for manufacturing processes involving the use of power it would appear to be more logical to express this power consumption in Btu. per unit of output (per ton of steel, for instance). The desirability of this will be obvious from an inspection of diagram No. 8 which shows the very large effect of the efficiency of engine room and boiler room equipment on the fuel chargeable for power generation. The same defect in expressing the power item results when the pounds of steam per ton of steel rolled is used as a unit.

In addition to the effect of engine room efficiency and boiler room efficiency there is the matter of the steam conditions which are supplied for the prime mover, either engine or turbine. The effect of steam pressure, superheat and vacuum makes the use of a unit of power consumption for rolling expressed in terms of the pounds of steam per ton of steel a completely un-

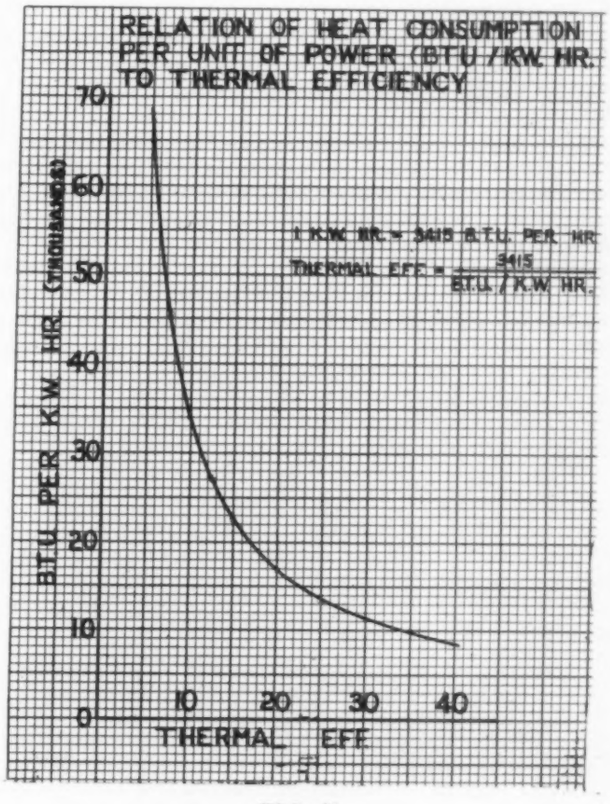


FIG. 21

satisfactory measure or standard of comparison for different types of drives. To bring this out more clearly, the effect of these three factors, steam pressure, superheat and vacuum on the steam consumption of a prime mover suitably designed for the different conditions, have been plotted graphically in terms of the consumption for a unit employing those specified for the

typical turbo alternator referred to previously, namely, 250 lb. gauge, 150 deg. F. and 29-in. (Fig. No. 19).

Summarizing the effect of all of these factors in terms of thermal efficiency for the overall power generating equipment is the logical step in analyzing power consuming processes. If, for instance, the power consumption for a process was expressed in Btu. per kwh., the engineer can directly determine with simple calculation, the thermal efficiency of the power system supplying that process. As an illustration of this, attached Fig. No. 20 showing the Btu. per kwh. plotted as a function of thermal efficiency, has been drawn.

To illustrate the application of the heat consumption basis for expressing the actual thermal economy where power is used in a manufacturing process the average Btu. per kwh. (14140) used for a typical turbine engine room has been combined with different boiler room efficiencies and plotted on the usual elongation diagram showing also the kwh. power consumption per ton of steel rolled (Fig. No. 21). This type of elongation diagram showing the Btu. fuel consumption per ton affords a basis for comparing the actual power cost of the finished product regardless of the type of prime mover which may be employed. It also lends itself to estimating directly the relation of the power consumption for a rolling process of any capacity to the total heat available in the fuel supply of the steel mill.

The operating record of the reversing equipments which have been installed to date, and which are operating under practically every possible condition, is the most convincing proof of the superiority of the electric motor for reversing mill drive. The ease and accuracy with which the performance of electrical equipment can be checked has made it possible quickly to discover and take advantage of changes in the apparatus or the method of application which would improve the reliability, flexibility and economy of operation. For this reason the development of the main features of the apparatus was accomplished in a comparatively short period. Manufacturers have become familiar with the requirements of the various applications so that no difficulty is encountered in selecting the proper equipment for a given mill operating under given conditions.

Electrification of old mills has in every case resulted in greater tonnage output and reduced operating cost. New mills equipped with electric drive have in many cases operated at greater tonnage rates than were considered possible at the time the mills were placed in operation. At first it was believed by some mill men that because the reversing motor may accelerate at a slower rate than an engine, the output of motor driven mills might be limited. Experience has shown that this characteristic of the motor has not curtailed production. In all cases the motor is rotating in the proper direction ready for the next pass before the ingot is ready to be entered; so the mill manipulation rather than the motor is fixing the minimum interval between passes. The ability of the motor to accelerate under load to the end of the pass without any danger of racing after the metal has left the rolls keeps the time for the passes short.

One of the chief advantages of electric drive is the ease with which the energy consumption and power costs can be determined for any desired period of operation. No "trial balances" or juggling of power records are necessary in making out the monthly electrical power costs for the various departments. The integrating instruments which record the power consumption of the various circuits are accurate at all loads; an error of 2 per cent is considered the maximum permissible departure from the true indication.

In one plant which uses reversing motors to drive a mill which rolls a wide range of sections, by obser-

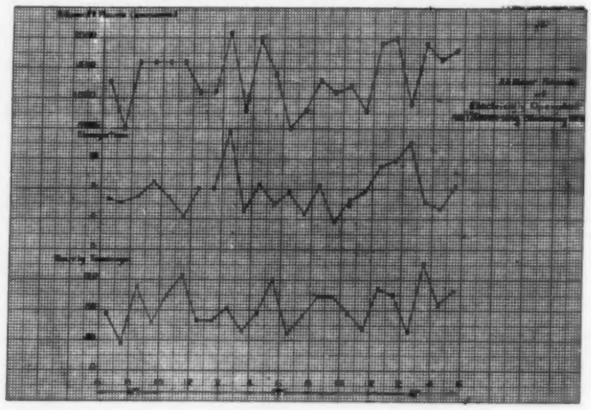

FIG. 22

vations over a period of time they have determined the average kwh. per ton for each section. They are thus able to estimate the power requirements for producing a new section and have a check on the power costs for any section.

Fig. 22 shows the hourly record of an electrically driven 40-in. reversing blooming mill for a 24-hr. period. The bottom curve shows the tonnage rolled each hour, the middle curve the elongation for each hour and the top curve the kwh. consumed by the reversing equipment each hour. While no data are

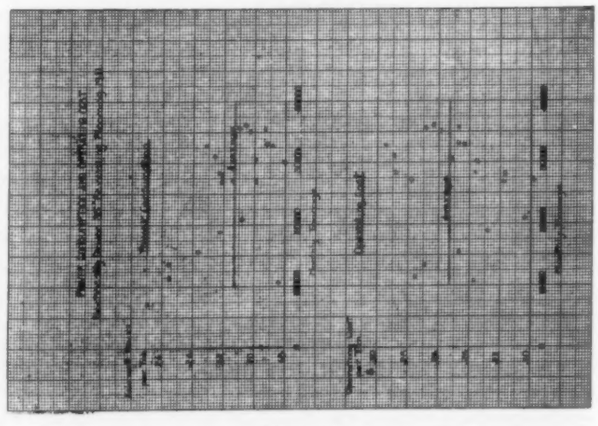

FIG. 23

available as to the temperature of the steel, which has considerable effect on the power required, it will be noted that in general the kwh. consumption for each hour is determined only by the tonnage and the elongation.

Fig. 23 shows the power consumption and operating cost per ton for a reversing motor driving a 35-in. blooming mill during 1919 and 1920. Operating cost per ton includes power, repairs and maintenance, miscellaneous supplies and motor room labor, but no

fixed charges. All figures are based on finished tonnage (2240 lbs.). The power consumption and operating cost per ton varies from month to month due to variations in average elongation but it will be noted that the tonnage rolled is not an important factor in determining these items. While the greatest power consumption recorded is for two months when production was less than 15,000 tons, it will be noted that for one month when production was only 10,500 tons the power consumption was practically the same as for the lowest record at 30,000 tons and above. The total operating cost figures show that the chances of the operating cost being below the average are as good for a low tonnage month as for a high tonnage month. This is due to the elimination of stand-by losses.

Fig. 24 shows the kwh. per ton of finished blooms (2240 lbs.). for a 44-in. blooming mill over a period of 3 years, during which time the monthly tonnage rate varied over a wide range. The power consumption includes the input to the flywheel set, exciter set, and blower and air washer. This mill was able to roll during months of low production with no greater power consumption per ton than when the production was high.

In Fig. 25 is shown the monthly finished tonnage (2000 lbs.), and power consumption per ton of an electrically driven 84-in. tandem plate mill for a period of one year. This mill has a two-high roughing stand driven by a reversing motor and a three-high finishing stand driven by an induction motor. It will be noted that the kwh. per ton differs for the same monthly tonnage rate due to variations in the material rolled. It is therefore evident that changes in monthly tonnage rate are responsible for variations of only a few per cent in the power consumption per ton.

The ability to roll a given product at a low monthly rate with practically the same operating cost per ton as for a high monthly rate is largely due to the fact that there are no standby losses or attendance changes when the mill is not in operation. Each day the mill rolls at its normal rate until the orders for that day have been finished. The electrical machines are then disconnected from the power lines and the flow of power to the motor room ceases until the next time the mill is started. Attendants are not required when the mill is not in operation.

On two previous occasions (Chicago convention, 1916, and Pittsburgh, December, 1919) tables giving the cost of operating one of the earlier reversing equipments installed to drive a 34-in. blooming mill have been presented before the association. This equipment is now in its 12th year of service and has rolled nearly two and one-half million tons of steel since it was placed in operation in 1913. This mill rolls comparatively small sections; the average being about 5 in. x 5 in. In Fig. 26 the cost table has been completed up to the end of 1923. The tonnage rolled during 1923 is greater than for any other year except 1917. During the period over which this equipment has operated the prices of all commodities have fluctuated widely, but it will be noted that the electrical operating cost per ton for this mill has shown only small variations and these variations have been practically independent of the general variation of commodity prices. Neglecting the first two years when the output was low, the total electrical costs including fixed charges on investment and overhead have varied over a comparatively narrow range.

The depreciation charge for the above equipment is based on a useful life of 20 years. The first reversing equipment built in this country, installed August, 1907, to drive a 30-in. Universal plate mill, gives indication that the useful life will be considerably more than 20 years. In an article published in September,

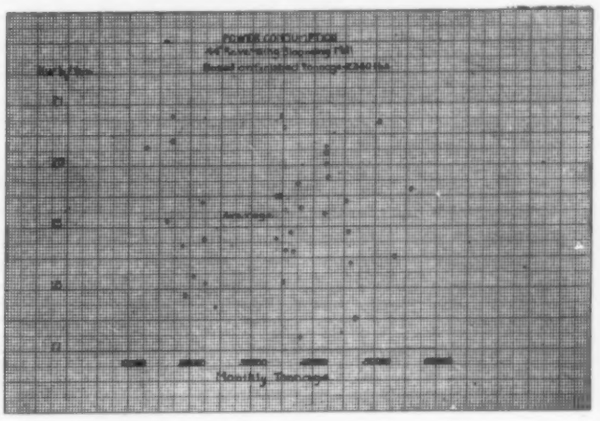

FIG. 24

1921, dealing with his operating experiences with this equipment, the electrical engineer of the plant included the following paragraph:

"It may be of interest to know something of the physical condition of this equipment at the present time. The original winding on the roll motors is still in service. The original commutators on both the roll motors and generator are in service, only about 1/16 in. wear being apparent on the roll motors since they were installed. The generator commutators show a reduction of about 1/16 in. every five years due to wear and dressing. The original bearings are still in service. Some wear on the motor-generator set bearings was noticeable at the end of 10 years. At

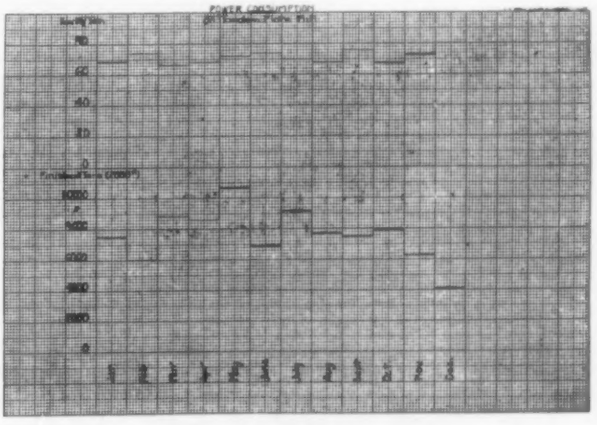

FIG. 25

this time a spare set of bearings was purchased to guarantee against bearing failure, knowing that they would be required eventually due to ordinary wear. These bearings have never been installed, very little wear having occurred during the last five years due to an improved oscillating device having been installed. Since the installation of this equipment something over 1,100,000 tons of steel have been rolled."

ELECTRICAL COST DATA

34" REVERSING BLOOMING MILL

ELECTRICAL OPERATING COSTS PER TON

| Year | 1913 | 1914 | 1915 | 1916 | 1917 | 1918 | 1919 | 1920 | 1921 | 1922 | 1923 | Average | % Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Months in operation | 9 | 8 | 12 | 12 | 12 | 12 | 8 | 12 | 11 | 12 | 12 | 120 | |
| Tonnage | 119230 | 92622 | 174460 | 238050 | 297224 | 276778 | 155515 | 272376 | 150018 | 178277 | 291432 | 2,245,982 | |
| KW. H. per ton | 23.9 | 22.8 | 21.5 | 19.8 | 20.4 | 21.8 | 23.4 | 21.3 | 21.2 | 24.9 | 22.0 | 21.8 | |
| Power Cost | .16 | .153 | .144 | .133 | .137 | .146 | .157 | .143 | .128 | .167 | .148 | .1454 | 85.6 |
| Repairs and maintenance | .0069 | .0092 | .0045 | .0102 | .0039 | .0030 | .0027 | .0010 | .0017 | .0097 | .0031 | .0046 | 2.7 |
| Miscellaneous supplies | .0045 | .0049 | .0025 | .0025 | .0029 | .0015 | .0051 | .0031 | .0036 | .0056 | .0036 | .0034 | 2.0 |
| Labor in operation | .0141 | .0161 | .0128 | .0100 | .0128 | .0147 | .0146 | .0218 | .0284 | .0248 | .0157 | .0165 | 9.7 |
| Total Cost | .1855 | .1832 | .1638 | .1557 | .1566 | .1652 | .1794 | .1689 | .1617 | .2071 | .1704 | .1699 | 100.0 |

TOTAL ELECTRICAL COSTS PER TON

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total operating | .185 | .183 | .164 | .156 | .157 | .165 | .179 | .169 | .162 | .207 | .170 | .170 | 51.2 |
| Interest | .078 | .101 | .054 | .040 | .032 | .035 | .041 | .034 | .052 | .052 | .032 | .045 | 13.6 |
| Depreciation | .065 | .084 | .045 | .033 | .026 | .028 | .034 | .028 | .049 | .039 | .022 | .036 | 10.8 |
| Total main drive | .328 | .368 | .263 | .229 | .215 | .228 | .254 | .231 | .273 | .298 | .224 | .251 | 75.6 |
| Miscellaneous | .126 | .133 | .115 | .078 | .061 | .063 | .077 | .072 | .085 | .092 | .072 | .081 | 24.4 |
| Total Electrical Cost | .454 | .501 | .378 | .307 | .276 | .291 | .331 | .303 | .358 | .390 | .296 | .332 | 100.0 |

FIG. 26

With regard to the delays on this equipment he wrote as follows:

"The sum total of all these delays, including those which might be considered as occurring during the development period, is approximately 525 hours. The entire operating time since the equipment was installed, neglecting Sundays, represents something over 100,000 hours, showing that delay caused by the failure of the electrical equipment was slightly less than one-half of one per cent of the time, and the major portion of this delay occurred within the first three years of operation."

Since September, 1921, there has been one delay of 11 hours and 25 minutes. This delay occurred when dust in the generator commutator spider ignited. In putting out this fire a chemical extinguisher was used and it was deemed advisable to thoroughly dry out the machine before placing it back in operation. The delays charged to this pioneer equipment have been exceptionally heavy owing to changes made during the first years of operation to improve the performance of the machines. The majority of the later reversing drives have operated with total delays averaging from one-tenth to two-tenths of one per cent.

That this universal plate mill drive is not being favored on account of its age is shown by the fact that during the year 1923 the previous high tonnage record, established in 1920, was exceeded by 4 per cent.

The reversing motor has long since demonstrated its ability to roll steel with the minimum operating cost which can be obtained. It has been demonstrated that the reversing motor is capable of rolling large tonnages. During the month of March, 1924, an electrically driven 40-in. reversing blooming mill which has been in operation since 1917 did more work than had been done by this mill in any other month. Thirteen thousand one hundred forty-four ingots having an average weight of 13,718 lbs. each, making a total charged weight of 80,800 long tons (2240 lb. per ton), were rolled. The average ingot section was calculated to be 26.915 in. x 26.915 and the average bloom section was 10 in. x 8¼ in., making the average elongation 8.8. This reduction was made in an average of 19 passes per ingot. The finished tonnage was 69,340.

The best mill records are usually obtained when large tonnages of a few finished sections are rolled, but the remarkable feature of the above record is that 95 finished sizes were rolled from five different sizes of ingots. The finished sections varied from 36 in. x 8 in. to 6 in. x 9 in. While there were only 180 tons of the 36 in. x 8 in. section, the output of 9 in. x 9 in., 8 in. x 8 in. and 7½ in. x 7½ in., all of which are smaller than the average section for the month, made up 39 per cent of the total tonnage.

The mill operated a total of 83 eight-hour turns or a total of 664 hours. Total delays for all causes amounted to 83 hours; making the net operating time 581 hours. The average hourly rate of rolling during the net rolling time was 139 long tons of ingots or 119½ long tons of finished blooms. While this mill has rolled 47 25-in. x 30-in., 13,200 lb. ingots to 28-in. x 8-in. slabs in one hour, no particular effort was made during this record month to roll large quantities of steel in a short period. The best eight-hour record for the month was 1,231 tons of finished blooms and slabs ranging from 11 in. x 7 in. to 36 in. x 6 in. The best 24-hour tonnage record was 3,061 finished tons.

If this rate had been maintained for the entire 83 turns the total finished tonnage would have reached 84,700 long tons with corresponding ingot tonnage of 98,800.

Of the total delays of 83 hours, only 25 minutes were charged to the reversing motor. Three delays were charged to the electrical equipment; two of 10 minutes and one of 5 minutes. One 10-minte delay was caused by improper adjustment of a field contactor by a new operator who was working on the control during a brief shut-down and who was unable to get correct adjustment before the mill resumed operation. The other 10-minute delay was caused by the burning off of a contactor shunt. The 5-minute delay was caused by the failure of the a.c. power supply to the exciter set. The operators were disappointed in having these delays, as they felt there was little excuse for any of them. However, these delays amounted to only one-half of 1 per cent of the total delays, and only one-sixteenth of one per cent of total operating time.

# *Engine Vs. Motor Drive for Reversing Blooming Mill*

By C. H. HUNT*

THE main paper presented this afternoon is a very valuable addition to the literature and data which has already been presented on the subject of reversing blooming mill drives and the authors are to be complimented on the complete and concise manner in which their subject has been treated.

I have enjoyed the paper fully and can appreciate the work entailed by its preparation.

In 1920 we built a new steel plant and installed a twin tandem compound condensing engine to drive the 40-in. blooming mill after carefully and thoroughly investigating the operation, installation and operating costs to be expected with each type of drive. This installation aroused a great deal of interest and criticism for the adoption of an engine drive at a time when the majority of new installations were being built with motor drives.

Not having seen an advance copy of the paper presented today, it was impossible to prepare a discussion, so I thought a statement of some of the facts that influenced our decision at that time and a few figures giving the results of operation on our mill and drive might be of interest at this time.

I do not wish to be understood as being partial to the steam engine, but rather impartial to either until it can be shown, after all things are considered, whether the engine or the motor will give the greater economy in the particular application to be considered, and would prefer the motor on equal basis from the standpoint of space required, ease of operation and cleanliness.

The drive most suitable for a given mill is of course the one which will roll a ton of product on that mill for the least money, giving full consideration of all items which enter into operating and fixed charges, and also consideration of the future schedule and tonnage which the mill may be required to meet; this latter consideration is one that is often overlooked.

Therefore not only in the selection of a main drive, but also in comparative figures, the following local plant conditions should be considered and the motor and engine placed on the same comparative basis under these conditions:

**Case No. 1.**

Whether the mill is a unit of a large steel plant with blast furnaces having surplus power available from a blast furnace gas engine driven central station—favorable to the motor drive.

**Case No. 2.**

Whether the mill is located in a plant short of power in its central generating plant when additional boiler plant capacity and electrical generating equipment, condensers and pumping facilities must be supplied in addition to the main drive proper—possibly favorable to the engine drive, due to increased fixed charges for the generating equipment and motor drive, particularly if the drive is to replace an existing engine of the simple non-condensing type with boiler plant nearby as is frequently the case since a compound condensing engine could be operated with far less steam, leaving a surplus for other purposes if needed, with scarcely any extra expense than for the engine with its condenser and foundation.

**Case No. 3.**

Whether the mill is a unit of a new plant with open hearth furnaces situated near the mill drive, which can be equipped with waste heat boilers to supply the quantity of steam required for the drive—probably favorable to the engine since the cost of extra generating equipment would create fixed charges to nearly, if not entirely, offset the gain in economy of the motor drive.

**Case No. 4.**

Whether the drive be for a small isolated rolling mill where the advantage of a small steam drive because of the small quantity of power involved, may be such that the overall economy of the steam drive will be better than that of an electric drive.

**Case No. 5.**

Whether purchase power is available at a low rate and without high demand charges and extras for peak load requirements, with sufficient guarantees that the price of the power will not be increased to prohibitive limits later on, so that a new installation may be made without the necessity of providing boiler plant and generating equipment or with purchased power replace an old existing steam drive so that only the cost of the drive itself enters into the fixed charges and where the steam would be valuable for other purposes if needed or in the case of an old worn-out boiler plant to be abandoned entirely—favorable to the motor drive.

**Case No. 6.**

Whether the reversing motor is quick enough on reversals to meet the requirements of the schedule without dangerous overheating. Any combination of the above conditions as may apply to the plant in which the drive is to be installed, must be analyzed before it can be determined definitely that the motor drive is more suitable or cheaper than the steam engine.

I think we are all more or less prejudiced in favor of the motor drive; however, the purchaser must endeavor to consider all propositions impartially in order to reach a true and fair comparison, and which to my mind are not always comparatively analyzed and brought out in papers or discussions before the engineering societies, and it seems to me that the engine builders have not been as diligent in presenting their advantage in applications where conditions and existing surroundings have enabled them to claim it.

I do take exception sometimes to comparisons which are presented in relative costs of rolling with

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*Presented at Pittsburgh Monthly Meeting, May 10, 1924.

engine and motor drives, as all factors are not always considered and some statements are misleading. Not long after our mill was installed, my attention was directed to the paper on "Review of Cost of Rolling Steel" by Mr. Stoltz, presented at the Philadelphia meeting, February 5th, and the Youngstown meeting, March 18, 1921, as abstracts of this paper appeared in the technical press and one morning the president of our company pointed out to me the statement that the steam drive mill requires 2½ to 3½ times the amount of steam that would be required by the electric drive and asked me how we could show equal or better costs of rolling with our engine drive if these figures were correct.

For the non-reversing main drive, there are few applications where motors will not show the best economy over the engine drive, since the total cost of the motor installation is not so much greater than an engine installation and the overall economy of the motor, receiving its power from an efficient turbine generating station offsets the difference in interest and depreciation, etc., on the larger investment in the majority of cases, although in this field also where conditions correspond to Case 2, 3, or 4 as given above, there may be reason for the installation of an engine, particularly the Unaflow engine with its high heat efficiency and low steam consumption, which under favorable steam conditions and condensing operation approaches the performance of the steam turbine and therefore reduces the overall efficiency of the turbine motor combination as compared with the Unaflow engine, so that the fixed charges plus operating costs in some cases would be in favor of the engine.

In my reference to engine drive, unless non-condensing engine is specifically stated, I have in all cases considered only the twin tandem compound condensing reversing engine, similar to our own, since no one would think of installing a twin simple non-condensing reversing engine to drive a mill today, and yet the comparisons between motor and engine drives in the paper referred to were made between the motor drive costs and costs with engine drives of this type, which have a steam consumption of anywhere from 1100 to 2500 pounds per ton of steel rolled, while tests on the twin tandem compound condensing engine have shown a steam consumption of from 440 to 870 pounds of steam per ton of steel rolled, so while the author was interested in showing the savings that could be effected by the installation of a motor drive to replace wasteful simple engines, the statement that the steam driven mill requires 2½ to 3 times the steam that would be required by the electric drive is misleading to anyone not familiar with the relative steam economy of the two types of steam engine drives, and the same statement can be made in comparing the simple engine drive with the compound condensing engine drive as will be seen by comparison of the steam consumption figures given above.

The elongation of the ingot must be taken in consideration in making comparisons of one type of drive with another as it influences the amount of steam or power required per ton of steel rolled and accounts largely for the variation in steam consumption figures, together with other local plant conditions such as the design of the engine, valve setting and the degree of skill with which the engine is handled when rolling, the steam consumption being increased by the number of idle turns the operator allows at the beginning and end of each pass, it having been found by previous tests that with little trouble the steam consumption can be increased 30 per cent and that one operator may use 10 to 15 per cent more steam than another and yet both may be considered experienced operators. Also the number of passes taken in reducing an ingot to a given elongation effects the steam consumption as the greater the number of passes the more steam is consumed in friction, acceleration and plugging at the end of the pass.

Furthermore, no comparison is true from the purchaser's standpoint unless the total investment for each plan is carefully figured and the fixed charges per ton of product produced are added to the other costs such as power, repairs, maintenance and labor. And it is not uncommon for the more economical operating costs estimate to be rejected in favor of a plan with lower initial investment. It is also difficult to obtain expenditure for changes in existing equipment which will show less than 15 to 20 per cent per year on the investment.

It seems to me that the compound condensing engine can not be dismissed from consideration with the thought that its greater acceleration and friction losses, due to greater weight of reciprocating parts, offset the gain in engine economy, as previous tests have shown only 14 per cent more acceleration and friction on a 44 and 70 x 60 twin tandem compound engine than on a 42 x 60 twin simple engine, and further, in the article to which I have referred, the author concludes that there is a difference of 50c per ton in favor of the electric drive over engine drive; this does of course refer to the simple non-condensing engine drive, but this difference is over 8c per ton more than we figure our cost of rolling per ton of finished steel, fixed charges and everything included.

Before our mill was laid down, a survey indicated that the possible developments of our plant could never exceed the demand for 75,000 to 85,000 tons of ingots per month. When the mill was laid out, it was somewhat of a problem whether we should allow room enough to permit a second bloomer being added at some future time, but since to do this would have cramped and congested the plant to the extent that cost of production might have been increased materially, I felt that a mill could be built to roll this tonnage over a single bloomer with proper measures of relief beyond the bloomer, but to do so it was necessary that the mill be very fast.

A study of the maximum tonnages of various mills showed that the engine driven mills had produced tonnages far in excess of the maximum tonnages produced by motor driven mills. This may of course have been partly due to local conditions, but it was evident from these figures that a mill could be built which would eventually roll our maximum requirements.

The nature of our finishing mills is such that about 60 to 65 per cent of the product rolled on the bloomer is reduced to about 45 square inches and the balance to light slabs 3 x 12 to 3 x 18 in. from 22 x 24 in. ingots weighing approximately 8,700 lbs. This meant approximately 11 elongations on the majority of the steel finished from the bloomer; however, provisions were made in the finishing mill layout so that when the future tonnage demands increased, the section delivered from the blooming mill could be increased to 8 x 8 in., or approximately 8 elongations.

This schedule created a demand for a drive somewhat in excess of the performance of motor driven

mills at that time, and the consideration of all these facts led to the selection of the engine drive.

Our steel plant consists of seven 100-ton nominally rated stationary open hearth furnaces; these furnaces have a record tonnage of 50,512 tons of ingots in a month, and since the plant is laid out for 100 per cent extension, it is evident that at that time the mill may easily be called upon to roll 80,000 to 90,000 tons of ingots per month.

The mill is located parallel with the open hearth department, with the mill drive at about the center of the ultimate length of the plant. Each furnace is equipped with a 600-hp. waste heat boiler and these boilers are developing an average of 80 to 85 per cent rating on waste heat alone, generating steam at 225 lbs. pressure and 125 deg. superheat.

The boilers are run auxiliary to the furnace, no additional fuel being added beyond the requirements of the furnace to assist the boilers, and in fact it has been found that the draft fans used in connection with the boilers are a considerable assistance in increasing the production of the furnaces. Therefore we had the advantage of having a good supply of steam close at hand for operating an engine drive, and the higher pressure and superheat available would give us about 10 per cent advantage over the lower steam pressures which are used on the majority of the present blooming mill engine drives.

In comparing the motor drive with the engine drive, we found that our first costs with either method of drive would be about as follows:

| | Motor | Engine |
|---|---|---|
| Cost of boiler plant—2,000 bhp. rated capacity | | $160,000 |
| Cost of boiler plant to generate power 1200 bhp. | $ 96,000 | |
| Cost of generating station 3150 kw. | 120,000 | |
| Cost of drive foundations and auxiliaries | 365,000 | 255,000 |
| Total investment for power | $581,000 | $415,000 |

Charging 15 per cent for interest, depreciation, etc., for the motor drive, we would have fixed charges of $87,150, and for the steam drive $62,250 per year.

In the last year our mill has rolled 520,000 gross tons.

And based on a production of 500,000 gross tons of ingot per year, the cost per ton of ingots rolled on the bloomer is as follows as compared with what we could expect with a motor drive:

Steam charged to blooming mill engine, including air pump, line condensation and boiler losses— per ton of ingots rolled ..... 650 lbs.

| | Per Ton |
|---|---|
| Steam cost | 17.20c |
| Water cost—4500 gpm. | 1.00c |
| Repairs, maintenance and supplies | 2.00c |
| Labor (not including night attendant and oiler) | 2.20c |
| 15 per cent interest and depreciation on investment of $415,000 | 12.25c |
| Total cost per ton rolled with engine drive | 34.65c |

Comparative cost with motor drive:

| | Per Ton |
|---|---|
| Power 21 kwh. per ton | 15.75c |
| Repairs and maintenance | .80c |
| Labor | 1.80c |
| 15 per cent interest and depreciation on investment of $581,000 | 17.43c |
| Total cost per ton rolled with motor drive | 35.78c |

Our costs throughout for the steam drive are given with liberal allowance so as not to unduly favor the engine and with allowance in the steam figures to cover any inaccuracies in their determination, with the cost of steam giving full credit at coal prices to departments furnishing the steam from waste heat, our total investment figures do not show as great a difference as would have been the case normally as we had an existing power plant that had been originally planned for these future extensions so that many items of cost in either case were already installed, in spite of which our cost of rolling does not appear to exceed the cost which we would obtain with a motor drive, and we have saved for other investments a difference of $170,000 in the first cost.

The mill has rolled 1,805 gross tons in 11 hours and 30 minutes actual rolling time, which is at the rate of 157 tons per hour and has a record of 55,747 gross tons in January of this year with 23 per cent lost time, most of the lost time being due to changing orders and waiting for steel, which was at the average rate of 122 tons per hour for the month.

For the last eight days of November, 1923, and working single turn of 12 hours, the mill averaged 1,665 gross tons per turn and at the rate of 150 tons per hour allowing for delays, equivalent to 86,500 gross tons or 75,000 finished tons per month when working double turn, and with sufficient steel capacity and additional heating capacity, which will be added when required, these figures can be increased 20 per cent. The above tonnages were made when rolling 6¾-in. square in 17 passes and when rolling to 8 x 8 in. it would not be necessary to use over 13 passes.

As a further illustration of the effect of the fixed costs on the subject in question, I wish to refer to Mr. R. B. Gerhardt's discussion of Mr. Stoltz's paper previously referred to, in which he has made a comparison of the steam drive and electric drive, considering the investment required to install the power generating equipment with the drives in both cases.

He gives the total for the steam drive as $700,000 and the total cost for the electrice drive $1,110,000, and figuring 15 per cent on the investment and assuming a monthly tonnage of 25,000 tons on either type of mill, the fixed costs per ton are given as 35c on the steam driven mill and 55.5c per ton on the electric driven mill, but to these fixed charges he has added steam costs derived from the simple engine drive, although his investment figures include a twin tandem compound engine drive. Let us then add to his fixed charges for the motor drive, the average total rolling costs which he has given for the 10 months, not including his November charges, which were high on account of abnormal rates and an overcharge for blast furnace gas, and his average cost would be 16.76c per ton, and let us add to the fixed charge per ton for the engine our rolling cost less the fixed charge or 22.4c per ton and we would have the total cost of 57.4c per ton for the engine and 72.26c per ton for the motor.

If we figure the investment charges on the basis of 50,000 tons per month, using the same rolling costs, the comparison will be 39.9c for the engine and 44.6c for the motor, which shows not only the effect of high initial investment, but also the effect of an efficient engine drive with low steam cost.

The high costs of rolling on many steam driven mills, even though driven by a twin tandem condensing engine, are often due to the high cost of steam

produced by old inefficient boiler plants. The case becomes entirely different when steam can be supplied by an efficient steam generating plant which must also be considered in our comparisons, as the cost per 1,000 lbs. may be as low as 25c with a modern plant instead of 40c to 50c as is the case in some of the old installations.

It has been my desire in the very limited time devoted to this paper to bring before those who are interested in this subject an outline for further investigations rather than any criticism of the very good work that has already been done, and it is through such societies and associations as the A. I. & S. E. E. that these subjects can be studied and analyzed, not only for the benefit of the engineers, but for the information of all who are interested in these costs and investments.

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# *Discussion in Connection with Heating Furnaces*

By A. F. MITCHELL*

THE continuous type of furnace is becoming more and more popular for certain classes of steel requiring thermal treatment. The possibilities of heat conservation, the mechanical features of operation and the comparatively small amount of floor space required are the outstanding features that attract attention.

This type of furnace is an ideal one for the conservation of heat; the products of combustion giving up their heat to the steel as they travel through the furnace, leaving at a comparatively low temperature at the stack. Another conservation of heat is due to the fact that the furnace can be charged and discharged without the opening and closing of large doors, or moving of the hearth. The small amount of manual labor and crane service required to operate this type of furnace, as compared with other types of furnaces, is quite a large factor to its credit.

While some of the valuable points of the continuous furnace have just been enumerated, it is well known that in many instances there is much room for improvement. Reference is made particularly to the lack of perfect combustion, the improper application of the heat, the lack of uniform temperature in the steel, the presence of skid pipe marks, the large consumption of fuel, and excessive oxidation. The objectionable features just mentioned and means to remove them or reduce them to a minimum, will be explained in detail later.

The Inland Steel Company of Indiana Harbor, Ind., recently installed a modern gas firing system on one of their large continuous billet heating furnaces in the 32-inch rail mill. This method of burning gas has been adopted extensively for firing different types of furnaces, by a number of steel mills during the past few years. The equipment was supplied by the Surface Combustion Company of New York City, N. Y., and the installation was planned and supervised by their engineers.

The interior hearth dimensions of the furnace are 19 feet wide by 53 feet long. The steel billets are mechanically pushed through the furnace on water-cooled skid pipes and leave by gravity onto a table of rollers. Two batteries of burners are placed across the exit end and the products of combustion travel the entire length of the furnace and out through flues to the stack. The fuel used is coke oven gas averaging 530 Btu. per cu. ft.

Six burners (A, Fig. 1) are directed in such a manner as to send the gas mixture above the steel. A similar battery of five burners (B, Fig. 1) is located across the furnace underneath the hot hearth, directing the gas mixture below the steel. The six upper burners have a maximum capacity of 20,000 cu. ft. of gas per hour each, and the five lower burners a capacity of 8,000 cu. ft. each.

Many gas burners in use at the present time are equipped with the old style two valve control, and require that the air for combustion be supplied by means of a fan or blower. The furnace operator is relied upon to see that the proper proportion of air is used. Other methods of burning gas are simply to deliver the gas to the furnace with little or no attempt to supply the proper amount of air for combustion.

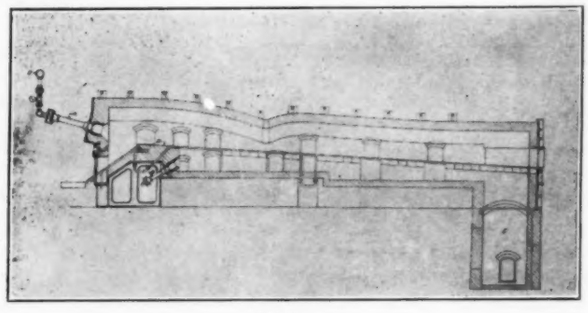

FIG. 1.

The methods of burning gas as just mentioned are very wasteful in the use of fuel, unreliable in operation, and productive of many unsatisfactory conditions both to the furnace lining and the steel being heated.

The design of a furnace with regards to its cubical content, location of burners, size of flue openings, or arrangement of damper control, will not in themselves be productive of ideal furnace conditions in operation. To produce ideal furnace conditions, the most important consideration is to supply the proper amount of air and thoroughly mix it with the gas in proper proportions to produce perfect combustion immediately upon entering the furnace. The device or

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burner should be so designed or constructed as to permit of automatically controlling both the gas and the air with one valve. It should be simple in construction, free from dangers due to explosions of the mixture, and positive in operation.

The burners used on this furnace are designed upon the principle of discharging a jet of the gas used at a maximum pressure of 10 pounds into an expanding tube of special design, and are regulated by opening and closing the gas valve alone. All of the air required for perfect combustion is automatically injected from the atmosphere in theoretical proportions, for complete combustion, independent of the skill or interest of the furnace operator. The proportion of air to gas does not change with the increase or decrease in the amount of gas being used. No blower or air piping is required with this system.

The end of the burner bricked into the furnace wall is water cooled and further protected with a special high temperature cement. The combustion tunnels leading from the burner nozzle through the furnace wall are also lined with special cement, which, with proper care, last indefinitely.

This system of burning gas has many points worthy of consideration. The most important of these are: The automatic proportioning and mixing of air and gas, reduction of scale at high temperatures, wide range of temperature control, and ease of operation, all of which promote maximum production and efficiency.

**Air for Combustion.**

Furnaces in which steel is heated to a rolling temperature usually are provided with recuperators or regenerators to preheat the air for combustion. The value of these air preheating installations can be measured by their initial cost, cost of upkeep, and amount of fuel consumption as compared with other systems not using preheated air. In some instances the value of preheating the air is not to be questioned. However, it is to be regretted that in many cases expensive preheating systems do not keep the fuel consumption and cost of upkeep down to the point that would be expected. Some of the causes that bring about high fuel consumption with preheated air are: The faulty construction and rapid deterioration of preheaters and regenerators, improperly constructed passages for the air and products of combustion, and improper methods of mixing and proportioning the air with the gas.

To obtain the best furnace conditions, it is very important to mix thoroughly the correct amount of air with the gas and apply it to the heating chamber of the furnace at the proper place.

The furnace at the plant of the Inland Steel Company is equipped with cast iron recuperators which are not being used in the present installation of Surface Combustion equipment. To dispose of the waste products of combustion without going through the recuperator flues, it was necessary to block off certain passages underneath the furnace and reconstruct the large flue leading directly from the furnace to the stack.

The burners used on this furnace simply inspirate the correct amount of air from the atmosphere for perfect combustion. The air mixes with the gas in the special tube of the burner without the use of valves, or the assistance of the furnace operator. The simplicity of this method of providing air for combustion can be readily appreciated.

**Heat Application and Control.**

The application and control of the gas mixture in any furnace will, in a large measure, determine its efficiency in operation.

A stratified condition of the gas and air mixture may cause streaked conditions of heat in the steel. This condition in many cases is never entirely removed from the interior of the steel, showing up during the process of rolling and too late to be corrected. Some of the results of this streaked heating of the steel is demonstrated by cobbles, broken rolls and other parts of machinery, mill delays, and excessive power consumption.

The various sizes of slabs and billets to be heated will require that more or less gas mixture be supplied to certain parts of the furnace. Conditions entering into the operation of a rolling mill will often require that the steel, when at the rolling temperature, be held for an indefinite period of time. It is very important to be able to meet this requirement without undue injury to the metal. Again, when billets differing in thickness are to be heated, more or less heat as the case may be, will be required underneath and above the steel to obtain the proper uniformity of temperature.

The conditions just mentioned were taken into consideration when the equipment for this furnace was being planned. The capacity of the burners was known, and they were located so as to provide sufficient quantities of the gas mixture to heat the steel uniformly from both the upper and under surfaces. Each burner is provided with a valve and pressure gauge, and the supply of mixture can be regulated as desired at that point. In addition to this, the six upper burners as well as the five lower burners are connected to separate manifolds, each manifold being controlled with a single valve. The valves and pressure gauges are all within easy access of the furnace operator, so that he is able to control the heat applied at any point.

The soft mellow heat, so much desired in steel for rolling purposes, can be attributed to the uniform temperature of the products of combustion in this furnace. This condition allows the steel to absorb the heat uniformly during the entire time it is in the furnace, without permitting stratification.

**The Hot Hearth.**

The purpose of a hot hearth in this type of a furnace is to assist in removing the cold streaks that are caused by the steel coming in contact with the water cooled skid pipes; also, to bring about a more uniform temperature throughout the mass. This applies particularly to the heating of billets of 6 in. or more in cross section.

It is not intended to enumerate in this paper the many troublesome results that are due to skid pipe marks and unevenly heated steel, as they are numerous, and vary according to the size of billets being heated, the chemical composition of the steel, and the requirements of the finished product.

In the present installation, the hot hearth occupies the full width of the furnace and is 4½ feet long, beginning at the top of the inclined skidway that leads to the table rollers. Underneath the hot hearth and skidway is a tunnel extending the full width of the furnace, which accommodates the lower burners; also the gas and water piping. The five burners are located equal distances apart throughout the tunnel to

permit the heat of combustion of the gas mixture to enter the furnace uniformly under the hot hearth and under the steel.

It will be observed that the highest temperature is applied to the steel immediately before it reaches the hot hearth. Therefore, with correct regulation of the gas mixture, the hearth can be kept in proper condition to remove the skid pipe marks, and to insure a very uniform temperature throughout the billet as it leaves the furnace.

The problem of eliminating skid pipe marks has been worked out in the present furnace to a degree of success that was not thought possible before. This can be entirely attributed to the type of burner installed, its location underneath the hot hearth, and the method of controlling the gas mixture.

**Overheating or Slagging.**

The evils of overheating or slagging steel for rolling or forging purposes are well known and need no comment at this time. What is of particular interest is the method of heat application whereby this condition can be reduced to a minimum. In this type of a furnace overheating and running of slag is principally due to improper application of the heat; to efforts to bring the under surface of the steel to the proper temperature too rapidly for mechanical working.

The skid pipes, being covered with steel throughout the entire length of the furnace, and heat applied from above only, it is natural that the hearth of the furnace and the under surface of the steel is very much lower in temperature than the upper surface. To meet the demand of the mill and keep it operating, it is obvious that the steel must be hot enough on the under surface to roll, and to accomplish this, in the limited amount of time allowed, the upper surface is very often overheated, and slag caused to run from the steel to the furnace hearth. In fact, this running of slag has been practiced so long that many furnace operators believe that the steel is not in good condition for rolling unless slag is produced, therefore cinder notches and cinder buggies are provided to receive the slag as it runs from the furnace. There are instances where the deposits of slag and oxide fills the hearth level with the skid pipes, at the exit end of the furnace, during a run of one week.

The application of heat on the present installation of continuous furnace entirely removes the necessity of overheating and slagging the steel. This is entirely due to the fact that the burners are located both above and below the steel; also to the ease of control of the gas mixture. In this furnace, after a run of one week, the small accumulation of oxide can easily be cleaned out by two men in one hour.

**Gas Booster.**

When using the high pressure system on coke oven gas the gas pressure is raised to a maximum of 5 to 10 lbs., depending on the range of control required for the particular operation. This pressure can be varied downward to approximately one pound when required.

In this installation, the gas booster is of the rotary displacement type operating at 300 rpm. and delivering a maximum of 150,000 cu. ft. per hour at 9 lbs. outlet pressure.

The demand for gas at the furnace varies according to the temperature of the steel when charged, size of billets being heated, and the rate of delivery required to keep the mill in operation. On account of the booster operating at a constant speed, and the demand for gas varying at the furnace, a by-pass line is installed, leading from the outlet to the inlet of the booster. This line is provided with a valve that is hand operated. It is obvious that the hand operated valve in the by-pass line is a positive method of operation, removing any possibility of delay or accident that might occur, due to the failure of an automatic valve to function properly. If the gas is clean and free from impurities, such as tar and napthalene, automatic by-pass valves would be preferred, but where the gas is found to be not thoroughly cleaned, the automatic valves fail to function properly a short time after being installed.

In industrial plants where high pressure gas is required to be distributed over considerable areas, a central boosting station should be installed. Gas under high pressure can be distributed in lines of comparatively small sizes.

**Furnace Capacity and Fuel Consumption.**

This furnace is required to heat various sizes of billets and beam shapes to a temperature of 2200 deg. to 2300 deg. F. for rolling. The sizes vary from 6 in. to 7 in. billets up to 24 in. beam shapes. The finished product consists of tie plates, splice bars, sheet bars, rounds, angles, rails and beams.

Approximately 80 per cent of the steel is charged into the furnace hot from the blooming mill and varies in temperature from 1200 to 1800 deg. F., an average being 1400 deg. F. The remaining 20 per cent is charged cold, and whenever it is convenient from the point of mill operations.

For comparison of performance between the recuperative type furnace in this mill and the furnace equipped with the Surface Combustion system, the turns when only 8x9 in. rail billets were reheated for rolling, are considered. All billets were charged hot from the blooming mill. The comparisons include the usual delays incident to mill operations in each case. In the former case two furnaces were required to keep the mill in operation, while in the latter case only one furnace was required. During a period of 31 turns the recuperative type furnace, using two furnaces, reheated an average of 26.4 tons of finished product per furnaces per hour, with a gas consumption of 4,630 cu. ft. per ton. The one furnace equipped with the high pressure burners, during a period of 12 turns, reheated an average of 55.2 tons of finished production per hour, with a gas consumption of 1,960 cu. ft. per ton. A comparison of the above figures shows an increase of 109 per cent in tonnage capacity, with a reduction of 58 per cent in gas consumed per ton in favor of the Surface Combustion furnace.

The maximum tonnage this furnace has reheated since being changed, over a consecutive period of several hours, without any delays, was 85 to 90 tons per hour, with a gas consumption of approximately 1600 cu. ft. per ton. In this case, as before, the billets were 8x9 in. for rails and were charged hot.

**Conclusions.**

The geat economic value of Surface Combustion principles of combustion, as applied to the continuous furnace here described, is certainly deserving of careful consideration on the part of combustion engineers throughout the country, especially in the steel industries.

The contrasts and references to other methods of reheating steel, as mentioned here, are not intended to underestimate the value of any method of burning fuel, but rather to point out the fact that advances are being made along this line, and that improved methods of combustion and specially constructed furnaces are destined to occupy an important place in all industries wherever heat is used.

The one fact alone, that of fuel economy, as brought out above, should command attention both from the standpoint of the individual user as well as the larger view of conserving the resources of the country.

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# *Modern Methods of Lubrication as Applied to Cranes in the Steel Mills*

By H. E. THOMPSON*

THE proper lubrication of cranes in steel mills is of prime importance; yet, it is a matter that has received but a comparatively small amount of attention, until a few years ago. Little or nothing is available in printed form for the education of those in charge of this class of machinery, and, while there are several types of lubrication equipment available, for the modern lubrication of cranes, trolleys, and similar equipment, no extensive effort has been made heretofore by the manufacturers to generally introduce improved methods of lubrication. As with most other modern improvements, attempts to make any radical changes along this line have been met with a certain amount of skepticism. It has remained for a comparatively few machinery builders and operators themselves to pioneer the way in this field.

In the steel mill, the steam engines, turbines, pumps, compressors, electrical auxiliaries, and even the roll and mill-drive bearings, are all provided with their individual oiling or lubricating systems. In the lubrication of all portable machinery, such as cranes and trolleys, numerous difficulties present themselves, regardless of the kind of lubricant used. These difficulties have heretofore had a discouraging effect on those who have attempted to solve this lubrication problem.

**Review of Older Methods.**

While all who are ordinarily familiar with this class of machinery in a lesser degree have some knowledge of the older methods of lubrication, it is fitting that we review the advantages, disadvantages and dangers incident to trying to adhere to the old methods of using individual oil or grease cups exclusively. Using ordinary individual grease cups is, no doubt, the most common method employed today, and this is true for a number of reasons. The machinery itself, like automobiles or any other commodity, is manufactured and sold under keen competition, and this has created a tendency on the part of most manufacturers to cut down their selling costs of the machines by the use of inexpensive lubricating appliances and other accessories, with the unfortunate result that some of the devices employed can hardly be considered any more than a make-shift. Grease cups are, therefore, most extensively used because they are the cheapest in first cost to the machinery builders. They are also the cheapest in first cost and installation to the crane user and, in addition to this, the filling of individual cups can be attended to by a cheaper class of labor, with little or no instruction as to how the work should be performed. No doubt, the greatest reason for adhering to older methods of crane and trolley lubrication is the fact that, until the last few years, no equipment has been available as a modern, efficient and reliable substitute.

The individual cup, as in past years, will hold its own in the future, on virtually all small bearings and pins for oscillating parts that are subject to little or no appreciable wear. On larger and more important bearings individual cups are rapidly being replaced by the method of lubrication where numerous bearings can be lubricated from a central source of supply. It is now possible that this supply may be either grease or oil. The greatest disadvantage of individual cups is, perhaps, the time required to refill, and the dangers to which the attendant is exposed in climbing around the rig, and working between gearing and drums, while engaged in filling cups scattered over the machinery. It is a well-known fact that there is a tendency on the part of a great many attendants to neglect cups that are in dangerous places, or where they are in rather inaccessible positions. The result is, the cups do not get the required amount of attention, and are allowed to remain empty over a period of operation resulting in a damaged shaft and bearing, lost time and labor, with the equipment tied up from productive operation while expensive repairs are being made.

Another serious fault of individual cups is the fact that they absolutely cannot be regulated in the amount of lubricant being dispensed. This is a serious fault, as different points require different quantities of lubricant.

Another most serious fault is that of the individual cup causing variations in the amount of lubricant being dispensed from time to time. A set of cups are filled, and changes in weather conditions or bearings take place, with the result that the lubricant passes into the bearing and out of same in a comparatively short time, and the bearing operates with little or no lubrication until the next filling of cups, which may be 24 hours later. This, in a great many instances, is too late, and only damage can result to the equipment from the improper lubrication thus occasioned.

The average workman does not fully appreciate the damage which can be done to bearings and other wearing surfaces by particles of scale or dirt getting into the cups, and this damage is multiplied by just as many times as there are individual cups to fill. Scale

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and dust as found floating around steel plants is highly abrasive, and especial attention should be given to instructing the attendant that every precaution should be taken to keep any injurious foreign matter out of the various cups when filling. With individual cups, the filling is quite frequently done directly at the bearing caps, which are often laden with an accumulation of dirty grease and grit.

The labor charges for attendance to individual cups, and the many chances of damaged equipment occasioned with their use, warrant giving the matter of improved methods of lubrication a very careful consideration. This should be a thorough investigation of the requirements of each individual crane, trolley, skip or hoist, and especially should this be done with larger apparatus, where the output of a plant is in so great a measure dependent upon the continuous and efficient operation of these units. A careful survey should be made to determine how to reduce the number of places requiring the regular attention of filling. Notations should be made as to the available locations about the rig for the one, two or perhaps three central sources of supply. Some trolleys are almost entirely lubricated from a single source, while other trollies and cranes may be operating under conditions where it is desirable to have two or three central sources of supply serving the bearings in separate groups. Under this condition, there is usually one supply for hoist drum gearing, another supply for propelling gearing, and a third supply for carriage propelling machinery bearings.

**Modern Methods.**

From the foregoing outline of conditions and results existing with the older method, there can readily be seen the need for a method that will eliminate as much as possible the chances of accident, neglect, damage, and resultant losses in unnecessary repairs and idle equipment which may at times slow up production.

**Central Sources of Supply.**

A fewer number of central sources of supply is the only real improvement that has as yet been provided for the lubrication of scattered bearings. A number of the larger manufacturers of cranes and trolleys have adopted the multiple forcefeed lubricator, of the ratchet type, for this purpose. This also applies to quite a number of the operators of cranes and trolleys who have equipped their machines in the field with force feed lubricators. The results have been very gratifying, not only to the machinery builders themselves, but to the mill operators having the equipment in operation. This change has been made possible through the production and marketing of reliable and efficient force-feed lubricators of the multiple type, having as many as 36 separate feeds in a single unit.

**Force-Feed Lubricators.**

One of the greatest advantages in a lubricator of this type is the fact that the outlet of oil from each feed can be independently regulated as to quantity required for each separate point to be lubricated. One manufacturer of trolleys uses these lubricators with 10 to 18 feeds, in connection with their ore trolleys.

A single feed is used for bearings having a length under eight inches, and for bearings up to 16 inches long two feeds are provided.

Where 12 feeds are actually required, it is customary to provide a fourteen-feed lubricator, which permits of having two feeds available as spares in case of an emergency. The two unused feeds are shut off, or have their discharge outlets piped back into the oil reservoir of the lubricator, which discharge pipe is removed and replaced with one of the lines leading to a bearing, if required. These lubricators are arranged with either right-hand or left-hand driving mechanism, so that the sight feed glasses and oil level gauge can be observed readily by the attendant.

**Requirements of a Lubricator.**

In the selection of a lubricator, care should be taken to see that its design and construction are suited to the service in which it is to be used. It should be of the ratchet type, so that operation of the plungers can be reduced to a minimum speed, if desired, by regulating the stroke of the driving lever. It is desirable that the plungers of the lubricators should not, at any point of their travel, extend through the exterior of the lubricator to catch and withdraw dust and dirt from the outside, which may be either discharged to the bearings, or greatly reduces the life of the lubricator through unnecessary wear. There should be a generously proportioned oil level gauge that will show the contents in the lubricator reservoir at all times. The interior mechanism should be simple in design and construction, and should be easily removable for inspection. It is also desirable to have a lubricator where each pumping unit can be separately removed, if necessary, without keeping the lubricator out of service, except for the few minutes required to remove or replace the pumping units in case of repairs or adjustment. The lubricator should be free from small spidery pipes, sight glasses that are under pressure, and other outside moving parts, or fine details of adjustments that will easily become damaged or worn in dusty surroundings. In extremely cold surroundings it may be desirable to keep the oil in a liquid state, and the lubricator should, therefore, have space available in same for the insertion of an electric light bulb to act as a heater. A long bulb, of small diameter, is available for this purpose, which is usually inserted through cover and connected with a weather-proof socket screwed to top of cover.

**Oil Feed Lines.**

One-quarter inch black iron pipe is usually used for the distribution lines. It is recommended that this pipe be pickled to remove any injurious scale or foreign matter from its interior surface. At outlet end of oil feed lines there is provided a check valve which is spring-loaded, to retain oil in the lines when the crane is at a stand-still, and also to permit building up an oil pressure in the lines. This pressure is limited to the compression resistance of the spring in check valve, and usually is not greater than 150 to 200 pounds per square inch.

This check valve is screwed into tapped openings at the bearings, and the inlet end of the check valve is provided with a union, threaded connection, which facilitates the easy removal of any bearing cap, if necessary. When the oil line pressure counter-balances the spring tension, the oil discharges into the bearing with a force tending to drive out any injurious foreign matter that may be in or near it.

**Lubricator Drives and Support.**

The lubricators are bolted to steel plates attached to the structural members, or a frame casting, and the lever is given an oscillating motion through a connecting rod driven from a pin which is set into the end of one of the gear shafts. This pin is set off center to act as a crank, and if lubricator is driven from a shaft of small diameter it may be necessary to screw a small crank disc on the shaft end, to get the radius necessary to give the lubricator lever its proper travel. One of the slower speeds in a train of gearing is selected as a driving point.

Where a piece of apparatus is engaged in doing considerably more propelling along the ways than hoisting, or vice versa, it is evident that two lubricators should be employed, one to provide for lubrication or propelling gearing, and the other for lubrication of hoisting gearing, so that only bearings in actual use are receiving their regular supply of oil. It must be remembered that one of the greatest advantages in the use of force-feed lubricators in this service lies in the fact that the lubricators start and stop automatically with the operation of the group of machinery they are serving.

The oil feed is reduced practically to a minimum, as the feed is consistent, positive, and reliable. It is conceded by all engineers that a small drop of oil applied at regular intervals is a far more efficient method of lubrication than large drops, or varying quantities applied through any hit or miss method.

The force feed lubricator, as a central source of supply, is highly favored by many engineers as an effective insurance against damaged equipment and delays in operation, that might otherwise be caused through inefficient lubrication. The cost of equipping a crane or a trolley with a modern, central, force-feed method of applying the lubricant is surprisingly low, amounting to a very small percentage, indeed, of the cost of equipment it is designed to serve, and considerably less than the losses which would be entailed through a single shut-down occasioned by burned-out bearings. Lubricators of this kind are practically fool-proof, and require a minimum of attention. They provide a dust-proof method of lubrication and, with ordinary care, are rarely the cause of any trouble, giving years of service, with little or no upkeep charge in their operation.

## DISCUSSION

**T. B. Little*:** It has been a pleasure this evening to listen to a very well prepared and well presented paper on crane lubrication. In this paper many good points have been brought out on crane lubrication as applied to the steel mill industry, and gentlemen, we, as representatives of the Keystone Lubricating Company, who are the largest manufacturers of high grade lubricating grease, come here tonight, not as fault finders or flaw pickers, but rather as ambassadors in the interest of not only more efficient crane lubrication, but also safe crane lubrication.

Among our systems of crane lubrication are first our Venango Funnel Cups. These cups on crane bearings in general has stood the test of time. These cups were first placed on electric traveling cranes back in 1910, and some of these steel funnel cups that were installed back in 1910 are still in service. There are quite a number of bearings on electric traveling cranes that we do not recommend the uses of the Venango Steel Funnel Cup, but where this cup can be used and a semi-solid grease is used in these cups, this has proven to be a very satisfactory combination and method of lubricant application to miscellaneous crane bearings.

Our Venango Steel Funnel Cup is equipped with a copper rod to convey the grease from the cup to the bearing. We desire to bring out one point in this particular connection. We do not depend on the copper rod heating to melt the grease to flow it to the bearing. It is our intention and desire that the grease shall be fed from the cup to the bearing exactly the same density as when it was taken out of the barrel and put in the cups, as we positively do not depend on the bearing heating up and heating the copper rod so as to melt the grease.

Our Venango Steel Funnel Cup and a semi-solid grease, has been and is now being used on bearings in saw mills in northern Minnesota. The same kind of cups and the same kind of grease are being used on bearings in the sugar mills in Jamaica. Here are the two extremes, winter and summer.

The Venango cups have successfully lubricated cranes in tin plate mills. As you undoubtedly know, if any oil or grease drops down on the sheets, they will not take the tin—the same principle applies in galvanizing sheet plants, and the Venango Steel Funnel Cups with semi-solid has overcome this condition entirely in the plants of several very large companies.

There are quite a number of bearings on electric traveling cranes that we find must be lubricated with force-feed, therefore we recommend cups which are equipped with automatic spring feed. These cups are supplied with 100 per cent springs for the purpose of feeding a regular density cup grease, but on a great many electric traveling cranes we supply these cups equipped with a 50 per cent spring for the purpose of feeding a semi-solid grease the same as is used in the steel funnel cups, thereby cutting out one density of grease.

As to the lubrication of traveling crane track wheels and trolley track wheels, a great many of our customers we supply with a long strand wool yarn elastic. This is a good grade of long strand wool yarn carrying a percentage of horse hair to make it resilient to hold it up against the trunions, and this combination impregnated with liquid grease and a liquid grease is used as a renewer on this wool yarn elastic. We also have a special product for the purpose of lubricating track wheel bearings. This is a very peculiar high temperature grease which is just packed into the cellar boxes and pushed up against the trunions and kept pushed up against the trunions, thereby eliminating the uses of wool waste and black oil. This product we are selling to some of the largest steel mills in the United States and repeat orders satisfy us that it is giving them the satisfaction that they demand. By the uses of this product we have been able to assist in the entire elimination of the dripping and wasting of lubricants on the runways of electric traveling cranes, bringing about a much cleaner, better and more safe condition.

Regarding the lubrication of electric traveling crane motors—we recommend a liquid grease. This liquid grease has every advantage of liquid oils and

*Keystone Lubricating Company, Pittsburgh, Pa.

none of the disadvantages. In the first place a liquid grease works perfectly under most all conditions in ring oil motor bearings and it does not break down or become thin and splash or spray out over the commutator, and eliminates the danger of burnt out commutators and fields as is often found where liquid oils are used.

The requirements of a suitable grease for lubrication of ball bearings are as follows: First, a grease used for the purpose should be the best quality pure mineral grease obtainable, free from moisture and corrosive materials. This grease should not contain any artificial weight making filler which would have a tendency to retard action of balls and would eventually dry out and become hard in ball races, defeating the purpose of the ball bearing. A semi-solid or soft cup grease should be used depending on the service.

Both electrical engineers and crane builders realize the importance of cutting the time used for lubricating a crane to a minimum, and keeping the crane on the move. Also the problem of safety comes up prominently. Eliminate the necessity of a man climbing over a crane and turning grease cups. Remove the human element as much as possible in lubricating a crane.

If crane is equipped with 100 cups and the operator screws down 99, the remaining cup that was not screwed down is the cup that gives the trouble, with the possible resulting shut down and consequent loss of production and creating unnecessary repairs.

These conditions were in mind when the Keystone Safety Manifold Lubricator was designed, and this system has been adopted by a great many electrical engineers for use on their equipment.

This system has proven a most practicable method of lubricant application for steel mill electric traveling cranes and equipment in general. Many bearings are lubricated from one central point, thereby eliminating the necessity of the crane operator or the oiler climbing around on the crane to screw down grease cups. The lubricator is placed in a safe position connected up with a manifold and each bearing has a separate pipe line running from the manifold to the bearing, and the grease is forced into the bearing under high pressure, and when Keystone grease is used in this system of lubrication there is no possible chance of the pipe lines becoming stopped up.

One large steel mill we have in mind, we are told, has adopted this system as their standard of crane lubrication. They have 18 or 20 cranes equipped at this particular time and are going ahead with the work of equipping the other cranes as rapidly as practicable.

We want to add that this Keystone Manifold Safety Lubricator is not limited only to the lubrication of electric traveling cranes, but it is adaptable to practically all classes of steel mill machinery. Descriptive advertising matter may be found in the official organ of the Association of Iron and Steel Electrical Engineers.

In reference to open slot boxes—for this purpose we have what is known as our Keyso Brick Greases, made in several densities and made in miscellaneous size bricks to take care of the different size open slot boxes as is found on some electric traveling cranes and steel mill machinery. This brick grease is just laid right in on top of the shaft and affords very excellent lubrication, even on bearings working under high heat conditions. This grease is made from a liquid grease for use in motor ring oil bearings working under very high heat conditions, down to a very hard brick grease for uses in bearings subjected to extreme heat conditions.

Regarding our system of lubrication, we will be very pleased to have the privilege of working with any of your safety first committees and will offer them the advantages of our experiences as gathered in the different steel mills, etc., as daily we are coming in contact with steel mill electrical engineers and master mechanics who convey to us some very excellent information regarding certain conditions that have caused them no end of trouble which they have been able to overcome by the uses of our materials and equipment.

Now if there are any questions that you would like to ask or any information that we can give you, we will be mighty pleased to attempt to answer these questions or give out any information regarding our system of lubrication.

**F. L. Koethen*:** I am sure I agree very heartily with the remarks regarding the necessity for using a good system of applying the lubricant, and also with the fact that more attention should be given to lubricants.

I understand that this is a rather small meeting this evening. That in itself is a direct indication of the fact that people do not give the proper consideration to lubrication. They consider it a secondary subject, an unimportant subject; and yet there have been a great many failures in operation in plants which were not understood, and which were entirely due to the lack of proper lubrication.

There has been a great deal of development in the modern theories of lubrication in recent years which has perhaps not been followed by the average man who is in charge of applying the lubricant.

I want to consider a little different phase of the subject than the question of what apparatus to use, or what lubricant to use, although I want to work around to that later. These are great days in the scientific study of oils and greases, substances which are soft and of complex nature, not as pleasant to work with as the more simple chemical compounds, and which therefore have not been studied as much in the past as they deserve.

Now, there has been a lot of really scientific study done lately on this subject, particularly in Cambridge University in England, and in Massachusetts Tech., and various other places in the country, which has shown that we were on the right track in some respects; in others we were not.

I plan to review briefly some of these developments, and then show how they affect modern lubrication. If we start to inquire why some lubricants are better than others, the first consideration which might occur is, why is not mercury a good lubricant? It has viscosity, it is a fluid, it would answer a good many laboratory tests for a lubricant, and yet, it is not a good lubricant.

The first thing that was noticed was that it has no wetting power — it does not wet the surface of a

*Tech. Director, Acheson Graphite Company, Niagara Falls, N. Y.

bearing. It runs right off. And that is as far as a great many people got for a long time.

When I was in college they told me you could take a lot of physical tests on lubricants, but you couldn't measure lubricating value. Lard oil is a better lubricant, just as a lubricant, than a mineral oil of the same physical characteristics. Why was that? Well, there were a number of things of that sort which indicated that there were a lot more important things than the physical tests. If we consider the original idea of how a lubricant worked, it was based on the theory of a wedge-shaped film. It is found that the shaft takes a position a little bit eccentric as far as the center line of the bearing is concerned. You have more clearance on the entrance side than the exit side. The oil coming in here acts as a pump, creates a bearing pressure which is sufficient to keep it separated.

That is the old Reynolds theory, which was one of the first theories of the reason why you could get actual lubrication, and it is the truth.

Under certain conditions, you can lubricate with almost anything. A high speed grinding spindle, for instance, lubricates on that principle with nothing but air. It is possible to run a high speed grinding spindle without any lubricant at all, just pressure of air sucked in is sufficient to hold the two surfaces apart. But if the speed drops, the lower the speed the lower the pressure, and we then find that in all of those cases there is a period in the starting and stopping of any machine, where if you depend only on the viscosity of the lubricant, you are going to have metal to metal contact some place in the bearing. Also, it is true that this pressure is not formed in a thrust collar, for instance (with the exception of the Kingsbury thrust bearing, which perhaps some of you are familiar with, where they have pie-shaped plates which take an inclined position). Reciprocating parts can't form this wedge-shaped film, and therefore very often at the ends of travel of the crossheads of engines, there is more wear than in the center. Cutting tools, of course, do not have this wedge-shaped film; and on gear teeth you can't form the wedge-shaped film.

Under these conditions the chemical constitution is more important than the viscosity. The viscosity is a controlling factor where you have wedge-shaped film, but that and the other physical characteristics are not so important when you get into a situation like this. That is one reason why lard oil is universally used for good cutting work on machine tools where the straight mineral oil of similar characteristics cannot be used. The difference shows up better there.

**Oiliness.**

That brings us to the question of composition of oil. It has been found that animal and vegetable fats were better than those of mineral origin for cases, such as we have on the far side of that chart where real lubrication was called for. Of course, there are disadvantages to the animal fats, viz.: price, rancidity and a tendency to gum, which made them undesirable. But as far as actual lubrication is concerned, they were better.

Now, in 1918, Southcombe & Wells, in England, discovered that they could add one-half per cent of oleic acid to mineral oil and improve the lubricating ability up to a point where it would be equal to the same oil compounded with 40 per cent of neutral lard oil. Lots of people laughed at this, that such a small amount of oleic acid would create such a big effect. They called it the "germ process", and said it was similar to the action of a germ on the body. It was found afterward that the system did actually improve the lubricant.

It remained for Robert E. Wilson at Massachusetts Tech. to test this theory out in six different ways and prove conclusively that there was an improvement in the lubricating ability. He also was able to take a lubricating oil and remove a certain substances from it and make it a very much poorer lubricant. He measured the lubricating ability primarily by means of a sliding weight determining the force necessary to move a little weight down an inclined plane, measuring the true static friction.

If he took some of that lubricating oil and shook it up with a large volume of iron filings, he found some substance was withdrawn from the lubricating oil which made it a poorer lubricant afterwards. Of course, in that case, he allowed it to come in contact with a very large area of surface, and this action was very much greater than would ordinarily take place. He also found a certain quantity of certain mineral soaps would greatly improve the mineral oil the same as the oleic acid, and he found that cresol, for instance, didn't improve it. He tried lots of different substances, and some worked and some didn't, showing it was a strictly chemical matter.

**The Adsorbed Film.**

He then proved, as did W. B. Hardy, working in Cambridge University, there was an actual deposit of a very thin film on the metal surface. Nobody is going to get excited about blocking up any ball bearings by that film. Hardy estimates, and Langmuir at the General Electric Company, concurs with him in believing, that a single thickness of molecules on the metal is sufficient to produce great results, and if you figure that out it is about 1/1,000,000 of an in. Actually, they found films a little thicker than that, but not thick enough to do any clogging. They did prevent metal-to-metal contact.

**Greases Rich in Lubricating Substances.**

These are perhaps results that you will be incredulous about, but there are actually good references to support it. I am not able to go into it very deeply tonight on account of lack of time. Wilson found that all of these substances partook of the nature of plastic solids rather than fluid substances — plastic solids—that was just "pie" for the Keystone and Gredag people, who had been using plastic solids in their greases, and is one of the explanations why a grease is so much better than an oil in cases of very difficult lubricant.

Of course, I am willing to agree that the Keystone people were in on this to a certain extent, but we have found there is a distinct difference in the type of the plastic substances which are used, and it is important to secure the right ones.

**Pure Graphite a Lubricant.**

I want to take up the question of lubrication with graphite. Of course we are all familiar with the fact that a pure graphite will tend to level up some of the roughness of the surface, and thus make it very much easier to lubricate. That is a well-established fact.

We have it in a great many applications in industrial work, and there is no doubt but that it takes place.

There is also another question which has been brought up. Referring again to mercury, we found that it is a poor lubricant, has a very poor wetting power — in fact, mercury has no wetting power at all. Lubricating oil on iron has good wetting power and is a good lubricant.

W. B. Hardy, over in Cambridge University, found lubricating oil on graphite had better wetting power than on metals. Therefore, it is desirable to produce a thin film of graphite on the surface of the metal. It only takes a very thin film. You are able to get better wetting of your bearing metal; your oil

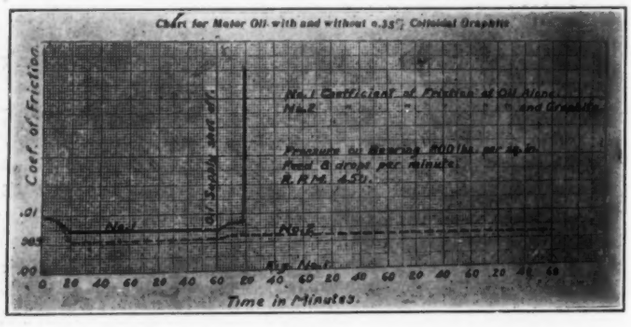



FIG. 1.

or grease film is more tenacious, is more secure because of the graphite. It is very important that you get reliable lubrication at all times rather than perhaps a trifle better coefficient under the ideal condition.

**Friction Tests.**

Here are some tests that were made by Professor C. F. Mabery, of the Case School of Applied Science, on the application of a small amount of graphite in lubricating oil. At this point the supply of lubricant was shut off. This is the plain oil, and the ordinate shows the coefficient of friction; after the supply of oil was shut off the friction rose until the bearing "seized", whereas with a small percentage of graphite in the oil he was able to continue operation for a considerable time after the oil supply was shut off, without marked increase in the friction.

**How Graphite is Made.**

Now, I want to take up for a moment, the method of manufacture of Acheson Graphite, and some of the interesting things about it. Fig. 2 represents an Acheson graphite furnace, about 30 feet long—a longitudinal section. The current goes in here, passes through the coke, and comes out here. This is the central charge. Practically any form of carbon can be transformed into graphite at the temperature of this furnace. The current passes through here and heats it up to a temperature that is almost unbelievable. We have never measured that temperature. The temperature loss is extreme, as soon as you open any part of the furnace, and we have never been able to get the correct temperature. We do know, if there should be a piece of rock, or iron or anything like that in the furnace, the temperature which can be obtained by passing this current through, and which is regularly obtained, is sufficient to volatilize all those impurities.

**Natural Graphite Not Pure.**

That is the same general process by which graphite is made by nature, with the exception of the fact that in this case the prehistoric deposits of coal and peat were turned deep into the earth in order to get that temperature. Only those veins of coal that ran deep enough to get a very high temperature in the earth were changed over to graphite, and there the pressure was enormous. The earth is in a plastic state down there, and you had actual conditions where the boiling point of all substances was greatly raised, the same way as you have the raising of water in the boiler—the higher the pressure the greater the temperature necessary to boil it. So in the manufacture of natural graphite in the earth, Mother Nature was unable to volatilize the impurities. In our furnace there is no question of getting the necessary temperature; if we find we have not purified and completely graphitized, it is only a matter of a couple more kilowatt hours per pound, and we can be absolutely positive that we have passed the graphitizing temperature.

**Gredag for Cranes.**

From the foregoing it can be seen that Gredag would be one of the ideal lubricants for crane lubrication, where the conditions of shock, of heat, of dirt, and variable speed exist, and that is actually true. We have had very good success in the application of Gredag, either through the old-fashioned cup or through the more modern multiple lubricators.

As a matter of fact, in our own plant, I was talking with our master mechanic the other day, and he only lubricates twice a week with his cups. I don't advise that for anybody, but they have had very good suc-

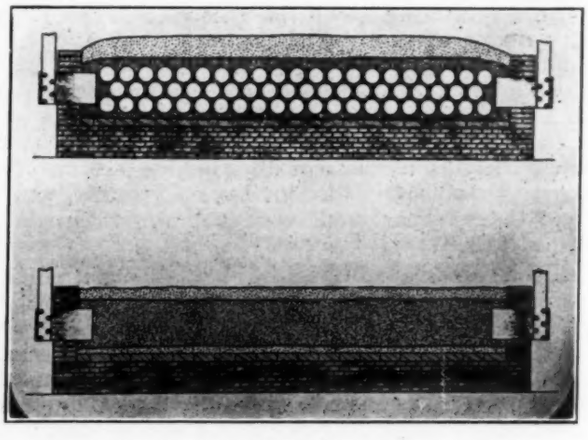


FIG. 2

cess lubricating with Gredag 52 on the cups, only applying the Gredag twice a week, because we get this adherent film which prevents metal to metal contact. We have a greater margin of safety in the case of Gredag and are able to use a softer lubricant than would otherwise be required, because we have a greater film-forming power.

For lubricating the bearings and other positions on cranes, which would ordinarily be lubricated by cups, Gredag 52 is the ideal. It is a soft, buttery cup grease containing a small amount of Acheson graphite. In no case is it necessary to use a very large percentage of Acheson graphite, because of the fact that it is so finely divided and has such a great power of forming this very thin film on the surface. For

gears Gredag No. 314 has been found to be ideal to resist the strain and shock, also where subjected to temperature it resists that very much better than an oil or any of the other lubricants that we know of.

There are some cases where a manufacturer only wants to use one grease on the two applications, where Gredag 52 has been known to lubricate everything on the crane successfully, year in and year out, without any difficulty.

For the wire cables, subjected to great wear, dust, bending, extreme heat, etc., Gredag No. 17 or No. 19 is especially designed, for it is more adhesive than the others, and has the power of protecting.

**S. L. Henderson***: Our chairman said he wanted someone to start an argument. I don't believe I will start an argument because it would not be in order with such a mutual gathering as this.

Getting back to crane lubrication, I will go as far back as 1911 when this Association of Iron & Steel Electrical Engineers held their annual convention in New York, I belive a paper on crane lubrication was presented.

At that time the speaker had in mind lubrication systems that would make it more convenient as well as safe for the greasers, or the man who oils the cranes. We have learned of other methods here tonight, that no doubt show a vast improvement, sufficient however to clearly indicate, by the application of such, will without question, result in not only safer but better lubrication.

I would like to ask Mr. Little of the Keystone Company, what is the maximum speed for the satisfactory working of the liquid grease system?

**H. C. Cronk†**: A term Mr. Koethen used in sticking in my crop. He said something about "chlorine". How many of us around here have heard that? He didn't realize what thin ice he was traveling on when he said that.

I firmly believe two things are going to bring about a change in our lifting mechanism — they are, the safety point of view, which has been taken care of to a great extent, and probably has less weight now than a few years back in the average steel plant at least, although possibly in some of the isolated plants it still has considerable bearing; but I think the greatest factor is that our equipment must work 24 hours a day. They are exacting more and more from a piece of equipment installed in a plant, and it will have to work nearer 100 per cent of the time as years advance.

A great deal of that equipment has to be shut down to be oiled, as in this particular instance, cranes. We can't afford to lose the time necessary to shut down to lubricate. Besides, after we have shut them down — take for instance a crane handling 175 tons, it probably will have somewhere in the neighborhood of 100 to 125 grease cups. What assurance have we after the crane is shut down that the oiler hasn't missed some of those cups? Maybe one is all that is necessary, just as Mr. Thompson said in his paper.

Then we come back to the point where we must have some central point, or a few points for the oiler to go to to do his lubricating, with positive lubrication facilities at the bearings.

It is a question of whether speed, that is, in rpm. has anything to do with it, or rather a better term is, feet per minute, of a given shaft. That term, I think, came up a month or so ago in roller bearings. One of the papers mentioned feet per minute as being their basis of calculation. In our experience, what little we have had in experimenting with lubrication, we find that feet per minute is certainly a better and more reliable figure than rpm.

Mr. Thompson mentioned certain sizes on manifolds. I'd like to ask him if they have any definite rule for a given length bearing—that is, a number of outlets for a certain size bearing. He didn't mention it in his paper. I presume there is some room for that.

The question of cost of the fluid lubricant as compared with grease I am sure would be interesting. That comes up in my mind now in connection with some Keystone lubricators we are using where we experimented with a pressure feed system, under exactly the same conditions where we couldn't touch but a fractional part of the bearings with the pressure feed lubricator.

I'd like to ask Mr. Thompson also just why we have to have a ratchet plunger? Why couldn't we have a plunger that didn't ratchet, but made a continuous stroke as he described? The ratchet does provide an easy means of adjusting the stroke or a number of strokes, however.

In connection with the more solid greases which Mr. Little mentioned in connection with armature bearings, or bearings running at a comparatively high speed. How will that stand up on that type of bearing? That question comes up through experiments which were made, and I happen to know where in this particular instance a motor was involved. I don't recall exactly the time, but one end of this motor could be lubricated with practically any kind of a lubricant, it didn't make much difference whether it was grease or oil, it seemed to work about the same. The opposite end of that same motor could not be lubricated with anything but oil. We didn't use Gredag, we didn't know about it at the time. But anyway, there was a case where we couldn't keep that bearing from burning up on experiments except by using oil.

That comes back to the point of the wetting value which was shown on the chart, at least, I take it to be the wetting value, also of the reservoir which the oil has in the bearing. The oil carried up over the shaft has quite a cooling effect, although it heats up momentarily, when it drops back into the reservoir which is comparatively cold, it is reduced to some lower temperature. That is quite interesting from a lubricating engineer's standpoint, and they probably could make an explanation much more clear than I could.

On crane installations, the anti-friction bearing hasn't been mentioned at all in connection with the general run of crane shafting bearings, and it must be given due consideration. It is not new necessarily. We experimented a good long time ago; right now it is rather prominent in the minds of motor men. But it seems to me the roller or ball bearing must be given due consideration and must have a place.

In connection with the Keystone system of lubrication, they mention a copper rod for feeding grease. Just why copper? Why not bronze or wood, or felt or some other type of rod? Also, do you in any case

*Electrical Superintendent, American Steel & Wire Company, Cleveland, Ohio.

†Electrical Superintendent, McKinney Steel Company, Cleveland, Ohio.

give the heat of that copper rod any value? Our experience is that the rods will heat more or less. It depends again on feet per minute of the shaft.

It also might be advisable to explain the method of varying the flow of lubricant with your particular type of cup.

Mr. Little mentioned something about grease for journal boxes, but I would like to ask Mr. Thompson what their scheme is for journal boxes, if they have applied their scheme to journal boxes on the trolley or on bridges? It seems to me they are a big factor, one of the most dangerous points that a crane operator has to contend with even in our modern buildings where we have what we call oiling platforms. Yet occasionally a more or less serious accident is experienced.

Also, in connection with journal boxes, in Keystone's case, I'd like to hear a further explanation. I don't understand how the grease stays up; you say it stays up or is kept up, but I don't understand it, and there are possibly more in the same predicament as myself.

In the Keystone system, how do you govern the flow of grease from the manifold to a bearing, for instance, if a bearing is double the distance away from another one, what plan have you for being sure that the grease reaches that bearing and not several others that are closer?

**J. B. Shaver*:** I too, came here sort of unprepared to go into any discussion about lubricating cranes. I would like to remark, however, that this is one of the most serious handicaps to the manufacturer. I can point this out more easily by reciting a couple or three recent instances.

We have gone to considerable time and expense with lubricating manufacturers to determine a good lubricant for cranes. I have in mind one recent installation where we employed a system fully described here tonight. We placed that system on the crane, and after it had been in operation over a period of a few months, we were informed by the executives of the company that our crane wasn't operating efficiently, and on inspection we found that the grease lubricating system employed on the crane had been absolutely destroyed. In other words, the bearings on the crane were not receiving any lubrication at all, and the result would be the burning up of the bearings.

You can go to all sorts of lubricating devices, but the particular thing that is being overlooked is the human element. I agree with Mr. Doolan, of the Morgan Engineering Company that by employing an inspector to inspect and oil all the cranes every day, and see that the oil system is kept up regardless of what system is used, good results should be obtained.

We have had two or three occasions where a majority of the trouble has been due to improper lubrication. First, the steel mill executives, mechanical and electrical men, will go to some trouble and expense in purchasing cranes to determine how much weight should be put in, what size gears, size of motors, size of drums, and other material entering into the crane mechanically, but pay very little attention to the lubricating system, and if we compile a lot of data and arrive at a very fair lubricating system, or one that would operate without much attention, we find it very difficult to obtain the cost of such a system. They will require the crane manufacturer to purchase that elaborate system and install it on equipment for the price of competitive bids, or competitive bidders who do not go very throughly into the lubricating end of it.

It has often been stated that in the case of an automobile, the life of an automobile is more or less prolonged by good lubrication. If lubrication of the automobile will prolong its life, why then cannot the same term be applied to cranes?

I feel that this meeting here tonight is one mighty good step in the right direction to prolong the life of cranes. As far as getting into a discussion of one system as compared to another is concerned, I believe we crane manufacturers will have to benefit by the experience of the steel mill men, and we hope to see some study given to the lubrication— in fact more study given to lubrication methods by the steel mill men themselves where they can actually try it out in their plants. If we put that installation on our own equipment, we may have a crane operating under entirely different conditions than exist in the steel mill, and therefore, speaking from the craneman's point of view, I feel if the steel mill men, and the Association of Iron & Steel Electrical Engineers can give a more deep, thorough study of lubrication, we crane men can benefit by their recommendations and prolong the life of a crane very extensively through the adoption of their recommendations.

**J. P. Doolan*:** I am glad to be with you this evening and have learned something from the talks we have had. I have only this in the way of experience.

I have charge of cranes and maintenance at the Morgan Engineering Company. In the past 10 years we have reduced our loss of time due to worn out gears, pinions and shafts and bearings to the minimum by employing crane oilers. The oiler handles all lubricating about the plant. Just recently we have combined the work of a crane inspector and crane oilman and we see a great advantage in this method— as it is necessary for him to go to each bearing and inspect it and inspect the gears and pinions and such parts that will wear and he can oil them at the same time. Previous to this method we had found that the two men were covering the same territory and that the oiler was not of the same caliber as the inspector, so we dispensed with the oiler and find that the inspector can do the combined work very satisfactorily. It doesn't take much intelligence to put grease in cups but it does take intelligence to decide whether gears and pinions are worn enough to be replaced. We find this has paid us wonderfully.

On our 50 cranes, if we installed equipment as described in one of these pamphlets, it would cost us about $7,500.00 for the lubricators, not including piping and labor of installing and we feel that there would be no advantage in placing the manifold on our cranes.

**H. E. Thompson:** Mr. Cronk's first question of a definite schedule for different sizes of bearings— we have no definite schedule for the number of feeds for the different sized bearings. That is something that was left to the individual taste of the crane manufacturers themselves. On some bearings they

*Sales Manager, Cleveland Crane & Engineering Company, Wickliffe, Ohio.

*Engineer, Morgan Engineering Company, Alliance, Ohio.

have put two individual feeds to a single bearing, usually on bearings that were over 8 or 10 inches in length, depending on their grooving or lack of it in order to get the film of lubricant throughout the length of the bearing. Where there was any doubt they put in two to make sure of it.

Mr. Cronk also asked why we adhered specifically to a lever or ratchet lubricator. In this connection it isn't absolutely necessary to adhere to a ratchet driven lubricator as long as there is some other means of reducing the speed to a minimum. It is possible to have a lubricator that is driven with a rotary drive, having a sprocket chain or a pulley with a belt. We don't advocate a belt because there isn't some one sitting up there watching to see whether the belt is slipping or not. It isn't positive. It would be the weak link in any central lubricating system.

Mr. Cronk also asked if we have applied lubrication from a central source to the journal boxes, and I presume he has reference to truck wheels. As far as I know we have not, but on the other hand, I don't see why there should be any reason for not being able to do it unless it would be in conditions something like a motor house where the motor generator sets and rotary converters, etc., are in operation where the building and surroundings are exceptionally neat, and where precautions are taken to see that any excess lubricator does not get down on the walls or panels and on the electrical equipment located along the walls. Out in the mills that is of less importance to guard against.

Mr. Doolan, of the Morgan Engineering Company, mentioned that he reduces the loss of time to a great extent with oilers, and he also mentions that the cost was $7,500 for 50 cranes, or in that neighborhood. I believe he has underestimated the cost of equipment for 50 cranes. It would cost him more than that, figuring in labor charges, etc. His figure would average $140 per crane, and the average is a trifle over that. As I outlined in my paper the cost of equipping one of these systems on a crane amounts to less than the cost of the hoist drum shaft and the bearings.

You people being crane builders appreciate probably to a greater extent than the ordinary consumer, the use of cranes, and have a proportionately greater number of attendants looking after them.

If a crane man is making a round of cranes, it is a pretty stiff job to get around to 50 in one day.

**J. P. Doolan:** He has been doing it for 10 years.

**H. E. Thompson:** There is a question I'd like to ask Mr. Little—How in a manifold grease feed is the oil regulated to the separate bearings, is it possible to throw it all down the outlet of the grease to these bearings independently in the proportions of the bearing requirements?

I might add in the discussion of the cost of these systems, that the National Tube Company, of Lorain, and possibly other plants represented among the people here, were pioneers in the field of applying force feed lubricants at a central source of supply, and as far as I have been able to learn this has been very satisfactory. Also, the statement was made by one of the gentlemen that a central system of supply would tend to keep a man from looking over the bearings at regular intervals.

He can, and he does look over them with ordinary grease cups, and with a very slight additional expense this inspector — and he would like his job much better if he only had to fill three or four lubricators than if he had to screw down all these cups in addition to filling them. In addition to filling them, he could get around and make his regular inspection and do it in less time. I believe the builders and operators themselves will agree with me also that lubricators forcing oil to the bearings regularly in a positive manner gives more insurance that you are getting proper lubrication to your bearings than you ever hope to have otherwise. The Brown Hoist Company are one of the firms who have found it so.

**T. B. Little:** Mr. Henderson asked regarding maximum speed for liquid grease systems. That will, of course, depend on conditions. Our recommendations are from 1500 to 1800 rpm., although some woodworking machinery runs high as 5600 rpm. and operation is perfect with this liquid grease.

Mr. Cronk asked regarding the size of bearings and the number of leads required from the manifold of the lubricator. A bearing from 10 to 16 inches long will require in most cases two leads.

In regard to the copper rod—we have also at times used wood, but copper is heavier and doesn't score the shaft when annealed; that has been our experience. In regard to the heat, heating of the copper rod has absolutely no value at all. It is the vibration of the copper rod on the shaft and the partial vacuum caused by the revolving shafts. We use in these cups a semi-solid grease, the grease feeding down to the copper rod to shaft. When shaft stops revolving the grease stops feeding. Right here in Ohio, this grease has worked on outside cranes perfectly when the temperature stood at 10 deg. below zero.

In regard to the grease for journal boxes. This material would be hard to describe and it is unfortunate I have not a sample here to show you. This material is packed up against the journal practically the same as wool waste and black oil and it is kept up there by pushing it up about once a day. In some instances the men have devised some mechanical means of keeping it in contact with the shaft, for instance, in one plant a spring is attached to one end of the box and run through the inside of box and on the outer end of spring a piece of fiber is attached and this keeps a constant pressure on grease and keeps it up against the shaft. This grease is working very well on cranes in the Pittsburgh District.

Mr. Thompson has asked about the flow of the grease from the manifold and the distribution of the grease. This is taken care of by a stop cock in the manifold. You can adjust the stop cock in the manifold according to the distance between the manifold and the bearing. For instance one bearing is near the lubricator and manifold, this stop cock will not be opened as wide as the stop cock that controls the flow of grease to some distant bearing. In this system when stop cocks are set in manifold all that is necessary is to put pressure on hand wheel of lubricator and grease is distributed just as it is necessary.

**F. L. Koethen:** I dont' want to get mixed up in this question of lubrication equipment and grease cups, because Gredag works satisfactorily in both devices. We can supply Gredag, which embodies all the value of these modern principles, for either system, as far as that is concerned.

As to the proper method of figuring speed on bearings, there is only one right way to do it, and

that is by "feet per minute", and you will find in our catalog that classifications are made on that basis. The diameter of a shaft in inches, times the speed in rpm., divided by four, roughly gives you the feet per minute. That is a better way to figure than anything else.

The question of ball bearings and roller bearings is an interesting one. I am very strong for the anti-friction bearings for small bearings and wherever possible, but I don't think the ball bearing manufacturers themselves are willing to hold to the old idea that ball bearings don't need lubrication. The "ideal" ball bearing has only a point of contact with the balls, and there is no friction; but that ideal bearing is never made, because it has no load-carrying capacity. In order to carry a load they have got to make it in the form of the curvature of the ball, and then it makes contact at more than one point, and rubbing results. The Timken people, who by the way, have approved Gredag, have their bearings adjustable where the wear comes, and they say they must be lubricated. All bearings must be lubricated.

The question of the combined inspector and greaser I think is a very good point, even though you have the inspector operate a multiple system. The average greaser isn't fit to take a position of such responsibility. He should be a high grade man, as he has the welfare of the plant in his hands. Any combination of inspector and "greaser" should bring good results, and I am strong for it, because it would insure having a higher caliber "greaser".

# *The Freret Safety Enclosed Knife Switch*

By A. L. FRERET*

THE up-to-date steel mill man is "sold" on the idea of Safety First. The question today is no longer: Shall we use safety enclosed switches on our circuits—but—What type of switch shall we use? Realizing that the day was past when a knife switch in a tin box, even though it had an external handle, could be called a safety switch, the writer back in the early part of 1918 set himself to design a real switch that would stand up under the rough and exacting service of the present day steel mill. His labors resulted in the switch shown in the acompanying drawings, which has the following characteristics:

(a) Rugged—Heavy cast metal cover. Large current carrying parts with ample contact surfaces.

(b) Totally enclosed—All parts except the operating handle within the enclosing case.

(c) Externally operated.

(d) Positive quick make and quick break—No burnt blades or clips due to switch being left in partially open or closed position.

(e) Safe—Cover of enclosing case cannot be opened or closed except with the knife switch in the open position. When case is open all exposed parts are dead. An insulating barrier preventing contact with the "live" contact clips of the incoming line side of the switch.

(f) Easy to repair—All moving parts are attached to cover which is easily removed from enclosing case so that a spare mechanism can be substituted if necessary.

(g) Easily installed—Switch is held in place by four lugs, two top and bottom. Ample room for connecting cables to clip blocks. Insulating barrier protecting incoming contact clips easily removed.

The accompanying pictures show the switch in its original form. Since that time experience has shown that a few minor changes were necessary, which have been made in the present type of switch. The new switch differs from the one in the pictures in that:

(a) The enclosing case is provided at top and bottom with a boss drilled and tapped for conduit instead of the "knock outs" as shown.

(b) The insulating barrier protecting the contact clips of the incoming line side of the knife switch has been extended so as to completely shield the clips. The drawings show:

Fig. 1—Plan view of switch taken along dotted line 1-1, Fig. 2 and in direction of arrows.

Fig. 2—A sectional view of the switch taken along dotted line 2-2, Fig. 1 and looking in direction of the arrows.

Fig. 3—A sectional view of the switch taken with the cover raised showing how the operating mechanism is attached to the cover.

Fig. 4—A view taken looking into the top of the switch showing operating mechanism.

Fig. 5—Shows operating mechanism in the closed position.

Fig. 6—Shows operating mechanism in the open position.

Fig. 7—Shows method of fastening blades to shaft.

Fig. 8—Shows details of Dog used to transmit motion from external handle to control lever.

Fig. 9—Details of locking bar.

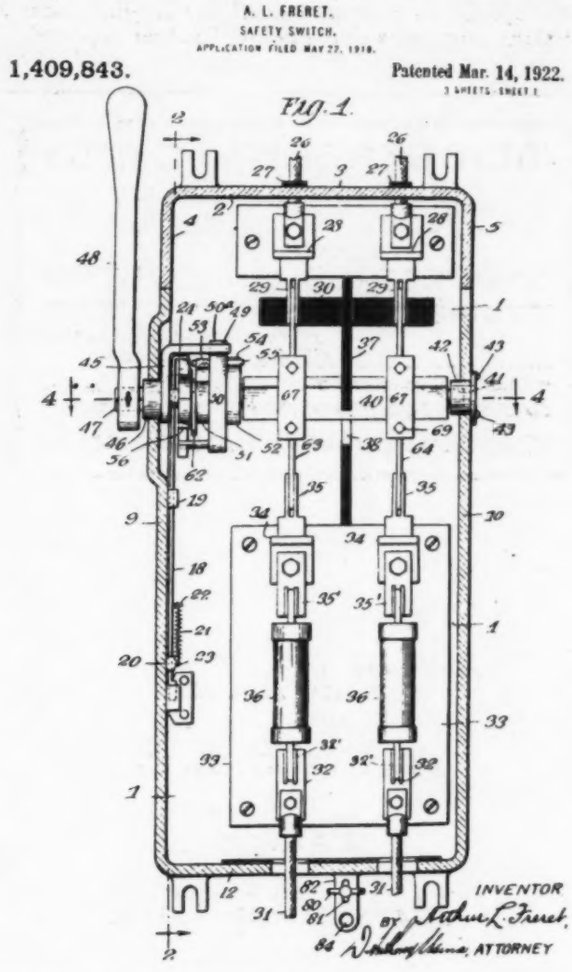
**Special Features—Operation.**

The quick make and break action is accomplished by a simple mechanism similar in principle to the common snap switch. This is clearly shown in the following description of the operation of the switch.

The opening movement is effected by turning the handle No. 48, Fig. 1, which is carried by the squared portion No. 47 of the driving dog No. 45 (see Fig. 8 for details of dog) and its motion is transmitted by the forked end No. 49 to the control lever No. 50 by engagement with a tongue No. 50a formed on the upper end of the control lever. (The control lever No. 50 is loosely mounted on the shaft No. 40 which carries the knife switch blades.) As the lever No. 48 is swung around in a clock wise direction as indicated by the arrow Fig. 5, the pin No. 55 carried therby will come into engagement with the hooked end No. 53 of the volute spring

* Assistant Chief Electrical Engineer, Tennessee Coal, Iron & Railroad Company, Birmingham, Ala.

No. 51 and a further movement thereof will wind the spring around the shaft No. 44 which at this time is held against rotation by the trip pawl No. 57 which is in engagement with the ratchet No. 56, (the ratchet is keyed to the shaft), the action of which is to store considerable torque within the volute spring No. 51. Continued movement of the handle No. 48 and control lever No. 50 will




bring the pin No. 61 carried by the control lever into engagement with the underside of the trip pawl No. 57 and raise the same as shown in Fig. 6. This releases the ratchet No. 56 and permits the shaft No. 44 and the switch blades carried therby to be quickly snapped around into a position shown in Fig. 6 by the energy previously stored in the volute spring, the movement of the switch blades being positively stopped by coming into contact with the rubber shock absorbing bumpers No. 70 carried by ledge No. 71 of the cover.

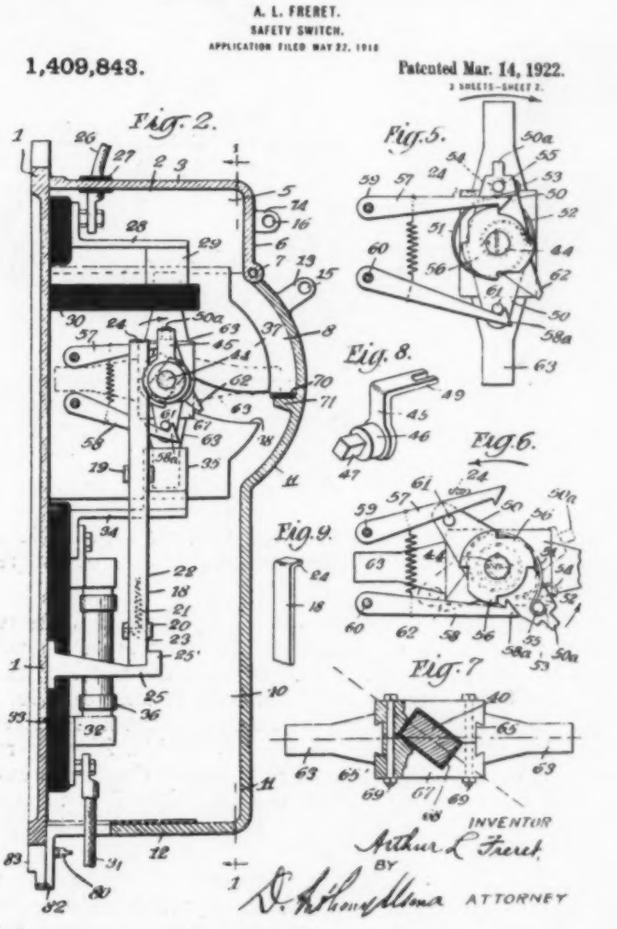
The closing operation is very similar to the above described operation.

The driving dog No. 45 rotates the control lever No. 50 in the direction indicated, permits the trip pawl No. 57 to fall into position to co-operate with the ratchet No. 56. Further movement causes the pin No. 55 to engage the hooked end No. 54 of the closing spring No. 52 storing energy in the said spring while the trip pawl No. 58 engaging the ratchet No. 56 prevents the rotary movement until the pin No. 61 of the control lever is swung around to a position to trip the pawl No. 58 from engagement with its co-operating ratchet, whereupon the switch blades will be quickly snapped to the position shown in Fig. 2 and 5, the movement of the control lever being arrested by the pin No. 61 engaging the hooked end No. 58a of the trip pawl No. 58.

As an added safety feature, provision is made for opening the switch blades independently of the snap switch mechanism in the event that for any reason this mechanism should become inoperative due to the accidental breakage of one of the opening springs or failure of other parts to properly operate. The auxiliary operating means comprises the cam No. 62 secured to the switch shaft. The pin No. 55 carried by the control lever No. 50 is of such length that it projects within the path of the cam No. 62 as shown at the left of Fig. 4. As thus constructed, it is clear that if for any reason upon the rotation of the control lever in the direction indicated in Fig. 5 the switch blades do not operate, a continued movement therof will carry the pin No. 55 around and into engagement with the cam No. 62 which being keyed to the shaft will cause the rotation thereof thus effecting an opening movement of the switch blades.

**Locking.**

In operation, when the switch is closed the parts are in the position indicated by Fig. 1, 2 and 5, the hinged




cover being locked in the closed position by the co-operation of the spring actuated locking bar No. 18 carried by the cover and the lug No. 25' of the bracket No. 25 secured to the back base 1. The cover No. 8 cannot be opened without first moving the switch blades to their open position by operating handle No. 48 which act will raise the locking bar No. 18 by reason of engagement

between the lip No. 24 thereof with the trip pawl No. 57 which is raised to the position shown in Fig. 6 when the blades are opened. Should the locking bar No. 18 fail to operate through breakage or any other reason the rectangular portion of the shaft No. 40 will be in such position (as indicated at "X" in dotted lines in Fig. 3)

A. L. FRERET.
SAFETY SWITCH.
APPLICATION FILED MAY 22, 1918.

1,409,843. Patented Mar. 14, 1922.
3 SHEETS-SHEET 3.

Fig. 3.

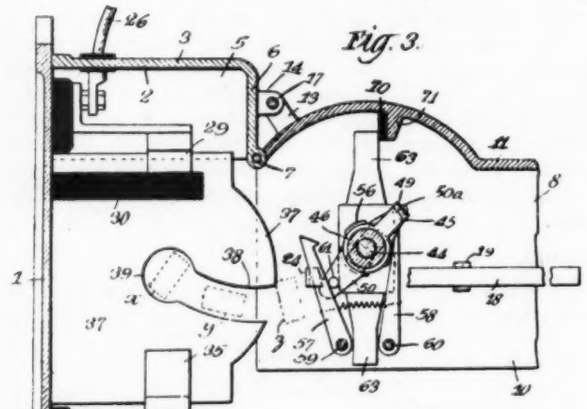
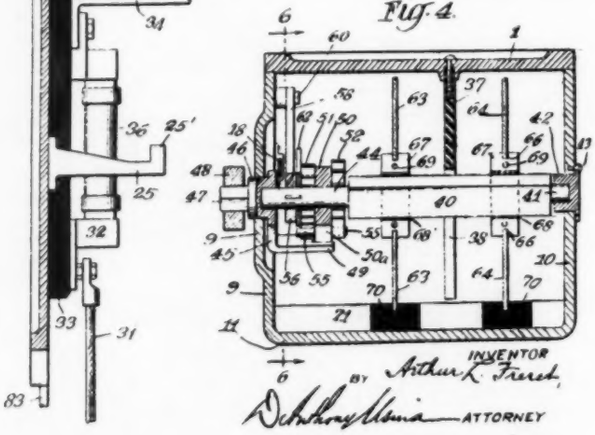


Fig. 4.



INVENTOR
Arthur K. Freret
BY
ATTORNEY

as to prevent the passage of said shaft though slot No. 38 which is of less width than the major axis of the rectangular portion of the shaft.

With the switch blades in the open position the rectangular portion of the shaft No. 40 will be so positioned that it will freely pass through the slot No. 38 in the insulating barrier No. 37 and the locking bar No. 18 will be raised a sufficient distance to permit its lower end to clear the lip No. 25' of the bracket No. 25, thus rendering all the parts in position to permit the switch cover to be swung upward about the hinge No. 7 to the position shown in Fig. 3, to permit access to the interior of the switch.

To effect the closing movement of the cover, the switch blades must be in the open position as illustrated in Fig. 3 so that the rectangular portion of the shaft No. 40 will be able to enter the slot No. 38 of the barrier and the locking bar No. 18 set to clear the lip No. 25' of the locking bracket No. 25.

It is clear that should the switch handle No. 48 be inadvertently moved so as to bring the switch blades into closed position when the cover is open it will be impossible to swing the cover about the hinge No. 7 to a position whereby the switch blades will come into contact with the jaws No. 29 and No. 35 due to the interference of the rectangular portion of shaft No. 40 and the barrier wall No. 37, as indicated by dotted lines at "Z", Fig. 3.

The first of these switches were put into operation in the latter part of the year 1918. Although they have been subjected to prolonged overloads ranging from 50 to 100 per cent, not a single failure has been reported.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# *Discussion on Mechanical and Electrical Analyses of 40" Blooming Mill Screwdown*

**By Membership**

**F. B. Crosby*:** I appreciate this invitation very much, but am not prepared to discuss the paper, and furthermore, I regret to say in the mills with which I am familiar, we have no screw downs. I have come here for information. I hope I am not stealing thunder from anyone else, but the question has been raised as to why we could not go still further and eliminate more of that gearing, using motors direct connected to screws. I would like to ask if there was an analysis made on that basis, and if so, with what results? To what extent, if any, dynamic brake is utilized in this drive? What proportion of reduction in speed, if any, is obtained by means of dynamic brake?

**T. P. McCallan†:** I am not familiar with the details on the screw downs of our Soho plate mills, but I might say we have all our mills equipped with motor driven screw downs On our 128-in. plate mill we have a single jack shaft with bevel gear drive, 100 hp. Crocker Wheeler motor. We have had very good success with this type of drive.

**W. C. Kennedy‡:** I have enjoyed very much the paper this evening, and am very glad to know that the association is getting more papers of this type. We have found that we have several different kinds of papers, some of which we can digest readily, others we wish to keep for future reference. I think this is one of the latter type. It is certainly putting on paper much vital information which is going to be more and more important in our work. I am glad to see the subject has been so thoroughly analyzed, particularly the use of motor drive on screws with some very interesting results.

Mr. Egan has given us figures on Blooming Mill screw downs, and while I have no additional information to offer on blooming mill screw downs, I can add a little in regard to plate mill screws, which, while they are operated under somewhat different requirements, still have to meet just as hard service. Sometime ago I gave a paper before the Philadelphia section on screwdowns and there were some figures given in that for comparison between blooming mill and plate mill conditions. While a blooming mill screw down will run anywhere from 1 in. down to as low as ¼ in. travel per one revolution of the motor, a plate mill screw down generally runs from 2/100 to 5/100 in. We roll steel plate direct from the ingot and therefore encounter quite a wide range of operations. With large sizes an ingot may range as high as 24 to 28 in. thick, and finish to ¼-in. plate or somewhat less. You can see readily the requirements are very hard to meet, because in breaking down the ingot, the screw down has to drop the roll perhaps an inch and finish with a very small increment. When rolling ⅜-in. plate, the motion of that screw down near the end of the travel will be approximately 4/100 in., corresponding to one revolution of the motor. For that work, we are using a magnetic full reverse controller, and a series wound M.D. 108 motor. The gear ratio is 3/100 of an inch travel of screw per revolution of the motor. The full speed going up is 1100 r.p.m. corresponding to about 3 ft. per minute. I think that is comparable with some of the figures Mr. Egan gave. To get that small increment and be able to control the motor on the finishing passes so we can get good results and make the motor turn about one revolution under accurate control we use an armature shunt point controlled from a two point master. The only thing that made this proposition possible is that accurate method of controlling the motor. I have actually seen that motor make as low as one-fourth turn or perhaps three or four teeth.

I appreciated Mr. Egan's paper very much and only hope we have more of them, because I think the point brought out by Mr. Egan is that we need these analyses of different installations and we will need them more and more in the future.

Mr. Crosby mentioned about gearing the motor direct. Our screw down is geared very nearly direct. In the paper I presented on the subject, 1921 proceedings, there is a sketch of it. It has a ratio of 22 to 87, about 1 to 4. The drive is geared direct to the worm shaft and the worm wheel operates the screw, so we have eliminated practically all gearing, with the exception of one back gear on the motor. I do not think that could be eliminated without having an exceptionally large motor.

**W. T. Snyder*:** On our blooming mill we have a one to one gear ratio from the armature shaft to the screw. I believe the fly wheel effect is about the same as shown in the second and third columns of Mr. Egan's slide shown on the screen. While the fly wheel effect seems to be high, the screw down seems to be very satisfactory to the operators. They say it comes as near to the hydraulic drive as anything they have had to handle. The first screw down was a geared-down drive with high-speed motor and was unsatisfactory and replaced with the present slow-speed motor drive

On the slabbing mill the motor is connected to a worm. The flywheel effect, judging from current curves, is about the same as in curve showing the lower fly wheel effect. The motor on the worm-wheel drive originally had a solenoid brake, which has since been removed.

**T. P. McCallen:** Has any consideration been given to lubrication, or the metal used in screw boxes in this district?

**F. O. Schnure†:** Mr. Egan is to be congratulated on his paper. We have two screw downs on our

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†Master Mechanic, Jones & Laughlin Steel Corporation, Soho Works, Pittsburgh, Pa.

‡Electrical Engineer, Worth Steel Company, Claymont, Del. Presented at Pittsburgh Monthly Meeting.

*Superintendent, Electrical Dept., National Works, National Tube Company, McKeesport, Pa.

†Electrical Superintendent, Bethlehem Steel Company, Sparrow's Point, Md.

sheared plate mill and universal mill, that we did not know much about because they do not give us any trouble. I think the 110-in. plate mill screw down motors ran four years without an armature change. Then we did not change it because the armature failed, but on account of low bearings. The universal mill has run three years with no armature failure. Our blooming mill presents a different story.

A point I would like to bring out in the study of the mechanical arrangement, is that the rolling schedule of the mill should be carefully considered. Our blooming mill is a combined blooming and slabbing mill and we roll slabs up to 38 in. wide; consequently, it is very essential that our screw down should have a high speed in order not to delay the edging passes. We feel when the time comes, when we are able to take the slabbing process out of this mill, that is, when we have a slabbing mill, we will be able to get into our screw down and possibly establish a higher gear ratio, which we think will, as the paper indicates, help matters considerably. Our rollers have no objection to the present arrangement; they seem to think it works fairly well. I would like to ask Mr. Egan if any consideration has been given to placing motors in parallel on screw down drives, also I might mention that we have tried a modified dynamic braking control, and it does not seem to give us anything that really is worth while. The roller nine times out of 10 plugs anyway.

**R. H. Keil‡:** I think Mr. Egan ought to be congratulated for offering a paper of this kind. It will be a big help towards encouraging the idea of going at the thing scientifically instead of the hit and miss system that used to be in vogue. I think the association is to be congratulated on having this type of paper.

**R. M. Hussey§:** Mr. Egan's paper is very interesting. He is to be congratulated on the manner in which he presented it. In 1918 I was connected with the application of motors to screw down drives and the matter of inertia was taken into consideration very carefully, and also the fact that it was a combination slabbing and blooming mill, as Mr. Schnure brought out. The approximate speed of screw travel was 20 ft. per minute and motors were selected to meet that speed, also to keep the inertia as low as possible. The fact that we were successful proves our calculations were somewhere about right. In the four or five years of operation of that screw down, we have lost only two armatures. That is a fast screw down; I think faster than those shown on these slides.

**F. Parken*:** On our 45-in. U.M. plate mill it is equipped with a Westinghouse brake, 78-in. plate mill an E. C. &. M. Q. brake, and on our 128-in. plate mill we have no brake but use the automatic control full reverse.

The rollers favor the brakes, as they can get more accurate gauges.

**O. Needham†:** In some of the blooming mills installed a few years ago, where they expected to do slabbing as mentioned by Mr. Schnure, they installed a control that would operate the motors in parallel when raising and in series when lowering the roll; the effect being to get high speed when raising the roll. I suppose Mr. Egan was not confronted with the necessity of backing the mill up for edging or anything of that kind, but I would like to ask if he has given such an arrangement any thought? Or possibly someone else might have such an arrangement and could give us some comments about such a scheme.

**R. F. Chaffin‡:** I believe that the question of control ought to be given a good bit of consideration on screw down application. The troubles we have run into with screw downs, which, incidentally, were put in by Mr. Egan, is with the current limit acceleration. We have a lot of trouble getting contactor to go in, due to mechanical condition of screw, and I believe a definite time element on screw down is a very good thing, although I have never tried it. Another thing we have encountered a good bit with screw down is turning them into forging press. It is good practice on our screws to have room on the end of the slab that you are slabbing down and screw down to size on it. That is a pretty tough job on motor and control, too.

**Arthur R. Leavitt§:** I would like to ask whether we could not obtain the same inertia in a screw down by using one motor rather than going to two motors?

**John D. Scully*:** I do not believe I can say anything more about screw downs than Mr. Snyder has said. The old type contactors we had on our controllers worked rather slow, which made it difficult for the roller. Later on we replaced the old type contactors with modern ones and the result was much faster operation and less work for the roller.

**W. C. Kennedy:** A question was asked about using two motors and running them in parallel up and series down. We designed one equipment to operate in this manner, but never found it necessary to add the second motor.

The question of constant time element acceleration has also been discussed. Where the load to be accelerated is largely one of inertia and low friction the best system to use is undoubtedly that of current limit acceleration or its equivalent. This is especially true where quick stopping by plugging and quick reversing is required. In a screw down as shown by Mr. Egan this is exactly the requirement, and moreover most of the inertia is in the motor armature.

I have found that a combination of constant time and current limit acceleration was particularly adapted to screw down work and very desirable.

In the chain of accelerating switches the first and last switches are controlled by current limit relays, while the intermediate switches have no relays at all, but simply close in succession. Ordinarily the time element of the switches themselves is entirely ample for the acceleration, and the discarding of the relays eliminates troublesome interlocks.

The first relay controls the first accelerating switch merely in plugging. The last relay controls the last switch and step of resistance to prevent the motor from being thrown directly across the line.

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‡Electrical Superintendent, Pittsburgh Crucible Steel Company, Midland, Pa.

§Electrical Engineer, Carnegie Steel Company, Duquesne, Pa.

*Assistant Superintendent, Electrical Department, National Tube Company, McKeesport, Pa.

In starting from rest the plugging switch closes immediately, and the motor starts to accelerate under the constant time element of the succeeding switches. If the motor does not accelerate fast enough the switches continue to close and the rate is increased due to the increased current.

This is very desirable, because if the rolls should stick or jam for any reason it is sometimes very essential that sufficient current be given to the motor until they are released. Since the closing of the last switch is limited by a series relay the final peak value of the current can be set to a safe amount in case it was impossible to move the motor at all. But, in case the rolls were jammed, ordinarily they would be released by the time the second or third switch closed and then the motor would be free to accelerate very rapidly up to full speed.

Under ordinary operating conditions the motor accelerates faster than the switches can close.

**P. McShane*:** I haven't anything to add to the discussion. I was very much interested in Mr. Egan's paper and he is certainly to be complimented for his efforts. I notice he said he used hydraulic counterbalance. We have a good bit of screw down talent here this evening, and I would like to know why hydraulic counter-balance is adhered to to such an extent? Mr. Chaffin brought out the point about control in a definite time. That probably would be an ideal proposition if there were such control available. Definite time relays are very seriously affected by temperature and oil leakage, and a motor driven, definite time element would not be practical for an application of that kind.

**R. Hussey:** There seemed to be a difference in screw speed between 1 to 10 in comparison with the total speed. Were they after that difference in speed, or did they get it on account of the hydraulic back pressure. Was it not possible to adjust that pressure to give a more even speed up to 10.

**J. H. Overpeck:** There is one possibility in screw downs which has been tried on manipulators. This is by using oversize motors. Mr. Egan seemed to indicate that, the higher gear ratio used with the same motor base speed, the more accuracy and speed could be obtained during the setting of the screw.

With this in mind put on one motor, or two in parallel, large enough to handle the load with series resistance in circuit sufficient to limit current to full load value at all times. Use reversing contactors only and a reversing master switch. Apply either with or without dynamic or friction brake according to operating preference. All accelerating contactors will be eliminated.

With this arrangement, motors cannot be overloaded nor can control and resistor. Quick acceleration will be possible, also quick stopping and with this arrangement all trouble on motor and control will be entirely eliminated.

**F. D. Egan:** Mr. Crosby's question on direcconnected motor: In this paper we have not analyzed the direct-connected drive, I would be interested in the analysis of that type of drive and a similar table to compare with those we have.

Mr. Hussey and Mr. Schnure spoke of drives they had that were not giving much trouble. That is where the mistake is made; we do not analyze the drive that is not giving trouble.

Mr. Crosby's question of dynamic braking and control. The dynamic braking current and contactor trouble are proportional to current and to the fly wheel effect of the drive. If you reduce the fly wheel effect you reduce the accelerating current and reduce contactor trouble and the necessity of dynamic braking due to having less inertia to stop.

Mr. Kennedy mentioned comparison of 40-in. blooming mill screw down with screw down on plate mill. They are entirely different, I would certainly be glad to have Mr. Kennedy supply similar data on their plate mills.

In rebuilding our drive while we held the fly wheel effect as low as possible we also made provision for ventilating the motors. On the main drive we have two air washers and blowers, one for the main motor and a spare. The spare unit is used for ventilating the fly wheel motor generator set, from this blower 7,000 cu. ft. of air is taken and the pressure boosted from 1½ oz. to 7 oz. and distributed to the screw down, table and manipulator motors. By forcing low pressure washed air through the auxiliary motors a low pressure is developed inside the motors that will keep dust and oil out of the motor as well as reduce the temperature of the winding.

Mr. Snyder and Mr. Farrington spoke of direct-connected motors. There is nothing I can add, I would be interested in hearing from them on the analysis of their drives.

Mr. Schnure mentioned a screw down drive where they are having no trouble; I think he should investigate this drive. On their 40-in. blooming mill, they are compelled to make a travel of 20 to 30 in. in order to edge the slab and return a similar distance to continue slabbing, in that respect their mill is different from an ordinary blooming mill.

On the question of speed I would refer to table 2 taken from that mill, it will be noted that the maximum speed from test in the up direction is 13.5 ft. per min., and in the down direction 6.95 ft. per min. or an average speed of 10.22 ft. per min. up and down.

Table 1 applies to the Lackawanna drive with a greater gear reduction, yet the average of the up and down maximum speeds is higher than the drive with the low gear reduction. The difference in speed up and down as shown on Table 2 would indicate that the jack pressure was too high.

Mr. O'Donovan spoke of inertia. When you secure the speed you desire and reduce the inertia as low as possible you have obtained the ideal reversing drive. While the subject of this paper has had to deal with the screw down drive, yet the same principles can be applied to any drive having a reversing cycle. First calculate the $WK^2$ effect referred to the armature shaft. Based on the rate of acceleration desired the accelerating torque can be calculated and with data on free running torque it can readily be decided what size of motor or motors will be required for the drive.

Mr. Parker spoke of two mills, one with brakes and one without brakes. A brake is required on a screw down drive, the size of brake and the necessity of dynamic braking is merely a question of the inertia in the drive. If you must plug the motor with

*Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa.

low fly wheel effect, low plugging current will be required.

Mr. Chaffin spoke of accelerating trouble. That mill was installed in 1911 and I believe this question has been properly analyzed and the new drives will prove more satisfactory. That drive was equipped with an old style G. E. brake that would handle the drive. Later the Cutler Hammer Company installed a disc brake that lasted about a week, yet the Cutler Hammer Company secured the order for the brakes for our new mill, indicating that the electrical companies are profiting by their previous trouble.

Mr. Leavitt asked why you could not put in one motor and have the same fly wheel effect. Assuming you are using the same type of motor, by installing one motor of the same size you would reduce the fly wheel effect of the armatures and brake wheels by one-half, but the free running speed of one motor would be approximately twice as high as two motors in series, and would have a stored energy four times as great. In case of trouble, with two motors in series one could be cut out and the drive operated with one motor until the defective motor could be repaired.

If you install a low speed motor to give the same hp. and speed of the two motors in series you are compelled to go to a special built motor. This scheme has been tried out by Mr. Snyder and Mr. Farrington.

Mr. Anderson spoke of the time element of switches. We analyzed our drive from the fly wheel effect. Control trouble is directly proportional to fly wheel effect. We reduced the fly wheel effect to a value that would allow the contactors to accelerate at their natural time element and yet keep the accelerating currents within 450 amperes. In addition we have individual series relays for each accelerating step that will allow us to increase the time for acceleration.

Mr. Lewis mentioned a squirrel cage motor. I would be interested in learning if any have been tried.

Mr. Hussey brought up the question of jack pressure. Between the up and down speeds there is a difference of more than 2 ft. per min. 11.2 down and 13.7 up as shown on Table 1, while on Table 2 there is a difference of more than 6 ft. per min. This difference is due to the jack pressure that is used to balance the top roll, spindle and carrier. The jack pressure on the drive shown in Fig. 1 is more nearly balanced than on the drive shown in Fig. 2.

Mr. Overpeck has me in deep water, he has put forth a new screw down drive and I am not in position to voice an opinion as it is not particularly clear. He should file a patent paper and then submit his design for consideration.

---

The September issue of the Iron & Steel Engineer will contain:

1. The papers to be presented at the 19th annual convention.
2. Official program of all the technical sessions of the convention.
3. Official program of all the events for the week of the convention.
4. Nineteenth Annual Banquet details.
5. Editorials from leading electrical and combustion engineers of this society.
6. Official list of all the exhibitors who will participate in the Iron & Steel Exposition, what they will display and who will be present.
7. Something about Pittsburgh.
8. List of plants which will be open for inspection.
9. Transportation details.
10. Entertainment program.
11. Miscellaneous information.

## IRON & STEEL EXPOSITION
## A. I. & S. E. E.

**Duquesne Garden** **Pittsburgh, Pa.**

**September 15th - 19th, 1924**

**ADMISSION TICKET**

**Million Dollar Engineering Exposition**
**ELECTRICITY - MACHINERY - COMBUSTION**

This ticket admits bearer to the Iron and Steel Exposition being held under auspices of the Association of Iron and Steel Electrical Engineers.

Exposition hours from 1:00 to 10:00 P. M. every day excepting Thursday when closing hour is 5:30 P. M. Exposition ends Friday evening 10:00 P. M.

This is a reproduction of the ticket which is being sent out to everyone interested in the Iron and Steel Exposition to be held under the auspices of the A. I. & S. E. E. during the week of September 15 to 20, at Duquesne Garden, Pittsburgh, Pa.

Admission will be by ticket only and anyone desiring one or more of these cards may secure them by writing to the headquarters of the Association, 706 Empire Bldg., Pittsburgh, Pa.

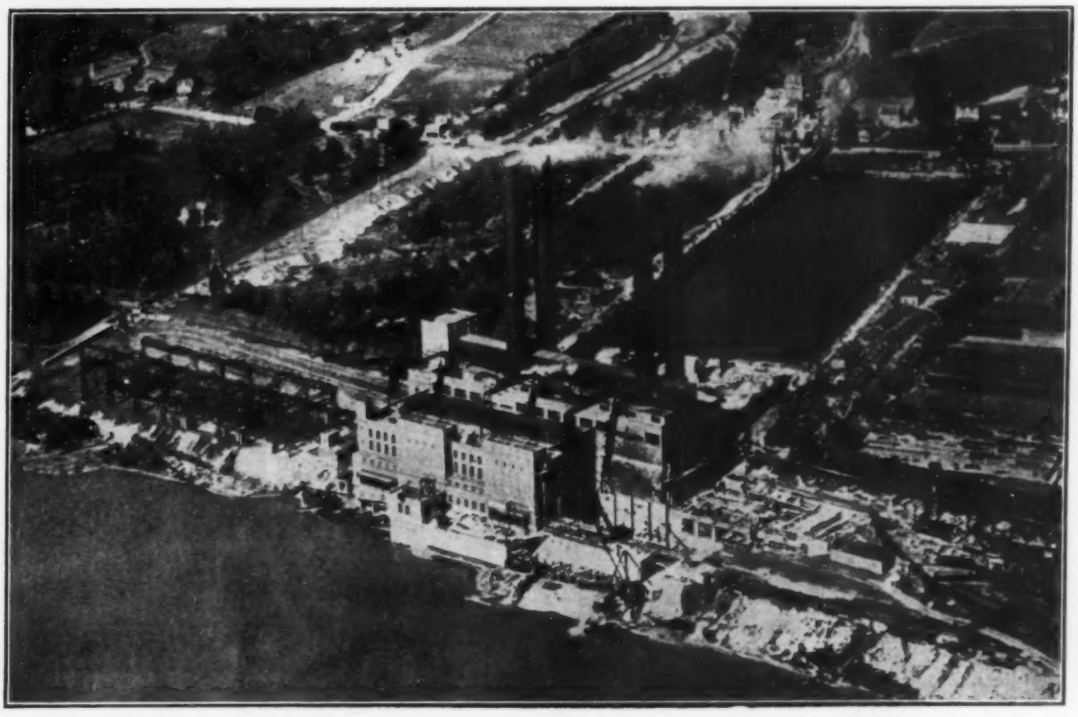
The Iron and Steel Exposition this year will even surpass the shows held for the past two years in Buffalo and Cleveland, and anyone who was fortunate enough to be present at either of these expositions will appreciate what is in store for them at the affair this year.

The membership of the Pittsburgh District has taken it upon themselves to be host to the out of town guests and, if possible, outdo the other district sections in the way of entertaining during the spare hours of the convention.

It has been quite some time since the Pittsburgh membership has had the opportunity to repay the many courtesies extended to them during their attendance at the conventions in other cities and having a proper appreciation for the many favors extended, they have called a meeting at the home office of the Association, 706 Empire Building, for Saturday, August 30, at which time final plans will be made for the many affairs to be held during the week of September 15 to 20.

Mr. A. J. Standing, chairman of the Banquet Committee, has solicited the co-operation of the members of the Association in making the banquet a success and from the responses he has received, the banquet promises to have 800 in attendance.

***Boost the Convention—Exposition—Banquet.***



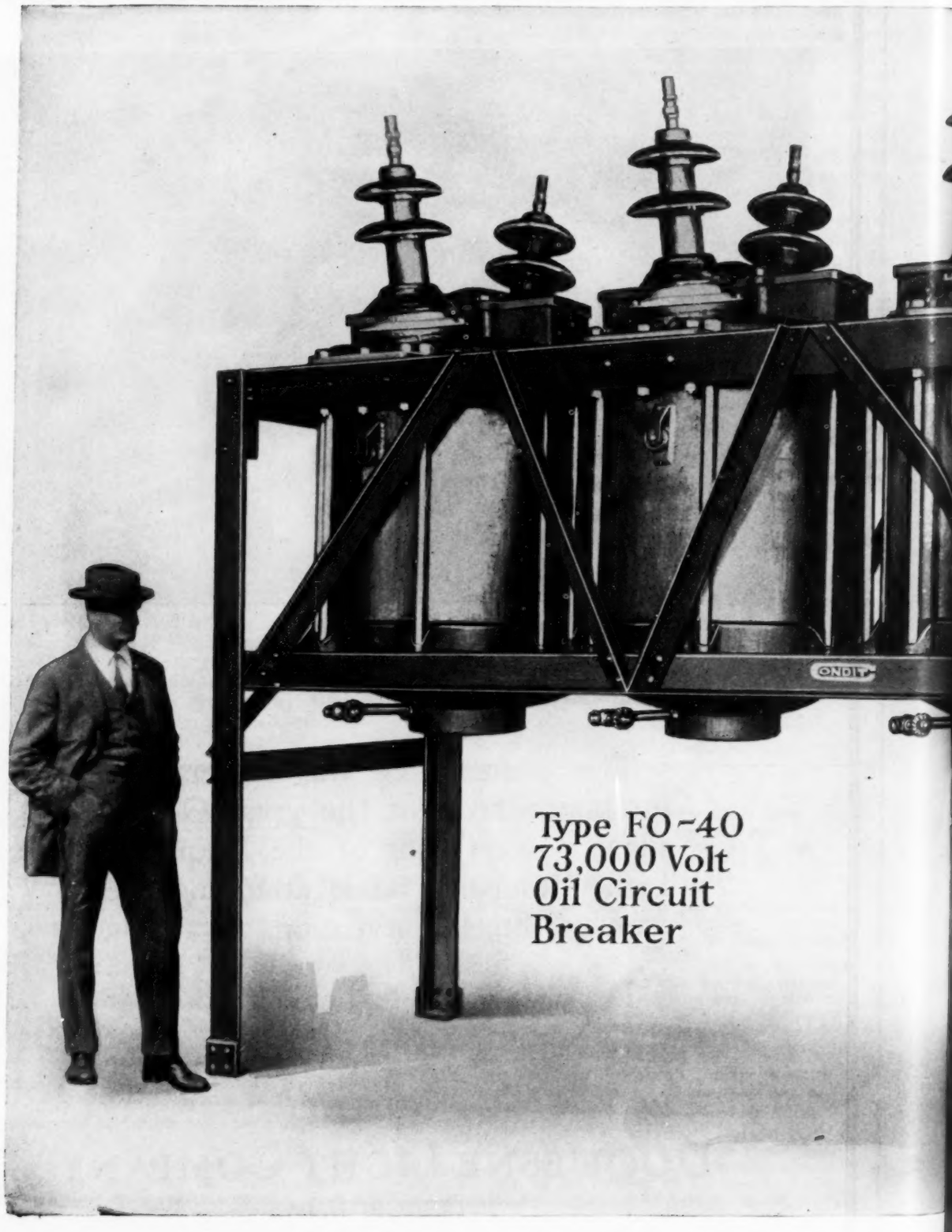
*To you, sir:—*

This is merely by way of being an invitation to visit the great Colfax super power plant of the Duquesne Light Company while attending the Iron and Steel Convention.

Details may be had at our booth at the Exhibit.

DUQUESNE LIGHT COMPANY
PITTSBURGH, PA.

*"Live in and Expand Your Business in Greater Pittsburgh"*

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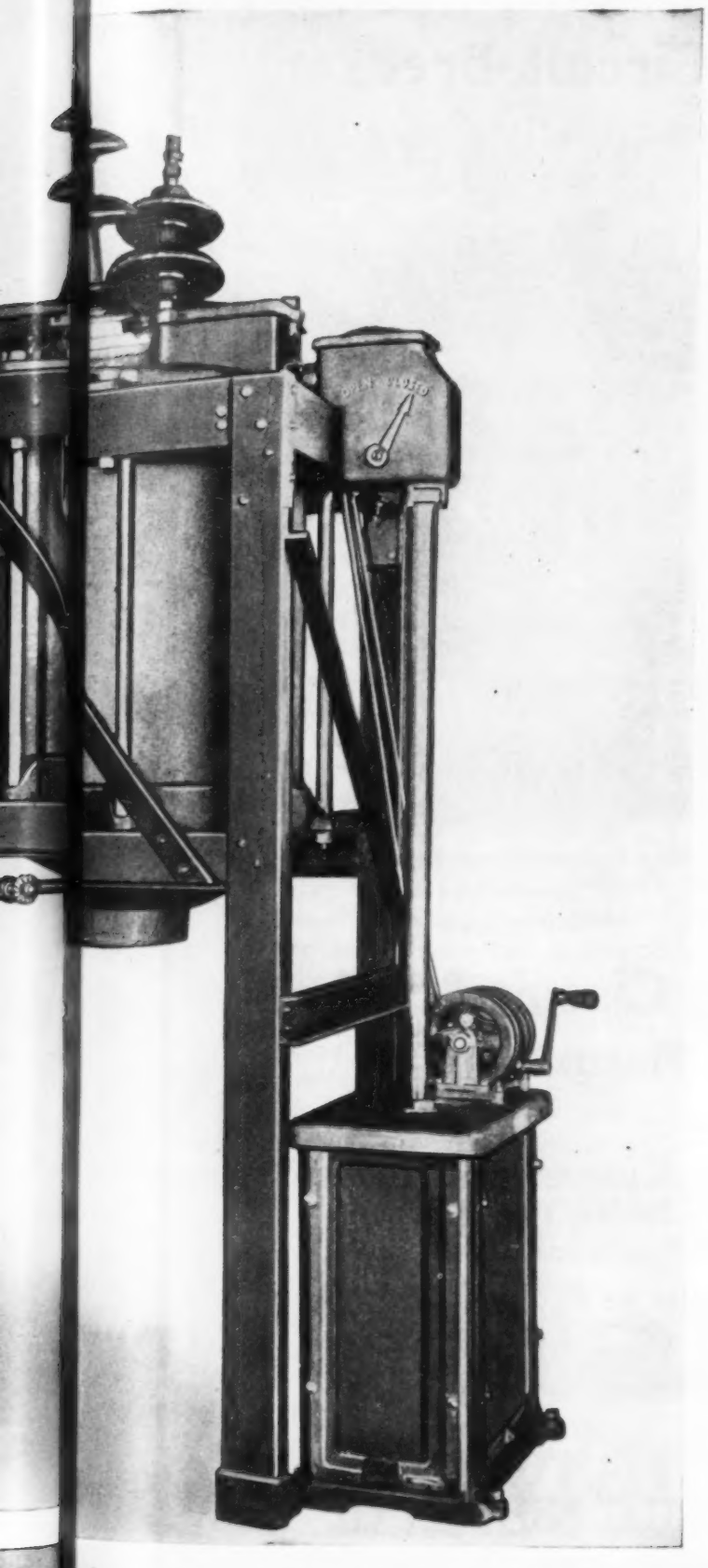

# -and now ready the all-steel construction

# FO-40
# 73,000 Volt
# 50,000 Volt
# 37,000 Volt
# Oil Circuit Breakers

*for*

1,000,000 KVA and under

"*Get in touch with Condit*"

**CONDIT ELECTRICAL MFG. CO.**
*Manufacturers of Electrical Protective Devices*
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LIMITED
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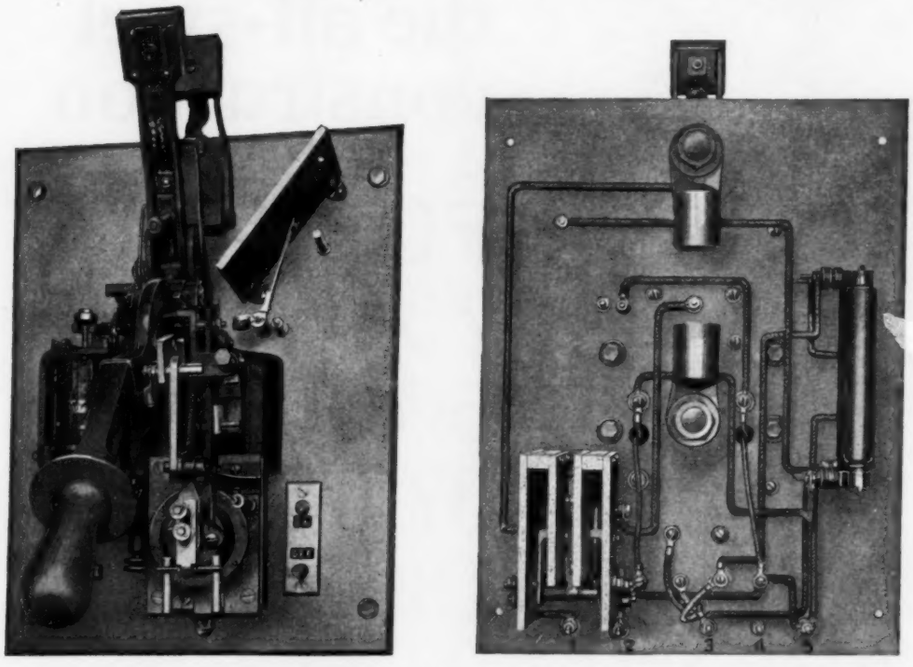
CONDIT

# A Manually Operated Circuit Breaker
## That Recloses Automatically



Front and Rear Views, Type "AHM" 600-Ampere Automatic Reclosing Circuit Breaker
With Removable Handle for Manual Operation

*or*

# An Automatic Reclosing Circuit Breaker
## That May Be Operated Manually

*either way*

This Circuit Breaker Embodies All That Is to Be Had in a Circuit Breaker
and Assures You High Grade Circuit Breaker Protection
At All Times and Under All Conditions

With That Refinement in Service That Can Be Had Only With

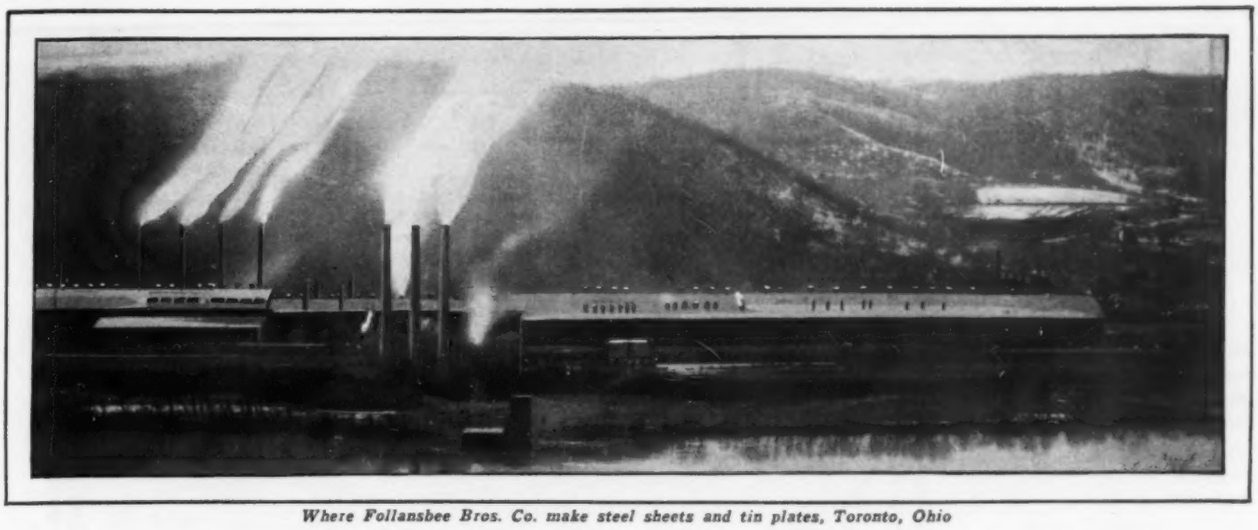
*The Circuit Breaker with Brains*

***Bulletin 314-F Gives Details.***

THE AUTOMATIC RECLOSING CIRCUIT BREAKER CO.

COLUMBUS, OHIO

PITTSBURGH: 1815 Oliver Bldg.
ST. LOUIS: 401 National Bank of Commerce Bldg.
WILKES-BARRE, PA.: 816 Miners Bank Bldg.
CHARLESTON, W. VA.: 317-318 Moore Bldg.

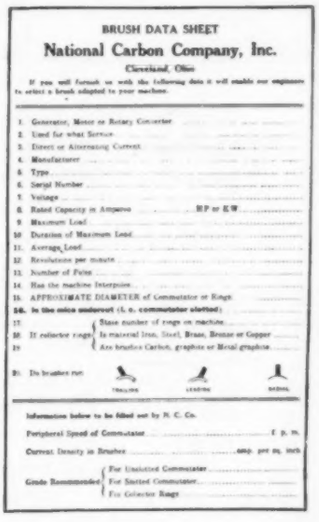


*Where Follansbee Bros. Co. make steel sheets and tin plates, Toronto, Ohio*

# Follansbee Does It

QUICK, simple, reliable, the National Carbon Data Sheet System is regarded by Follansbee production engineers as an important safeguard for their high quality sheet steel, tin plate and electrical steel sheets in all grades. This system, installed by one of our experienced sales engineers, determines the correct National Pyramid Brush for each machine and ensures that the correct brushes always will be supplied quickly on orders thereafter, and in the proper number.

Purchasing department detail thereby is lessened, confusion prevented, tie-ups avoided. There are two data sheets for each machine, one in the hands of the customer, one in our files. Ordering brushes by telephone, telegraph or mail may be simplified to these words: "Send set of brushes as per Data Sheet No. So-and-So." What could be simpler?



BRUSH DATA SHEET

National Carbon Company, Inc.

Cleveland, Ohio

If you will furnish us with the following data it will enable our engineers to select a brush adapted to your machine.

1. Generator, Motor or Rotary Converter
2. Used for what Service
3. Direct or Alternating Current
4. Manufacturer
5. Type
6. Serial Number
7. Voltage
8. Rated Capacity in Amperes ..... HP or KW
9. Maximum Load
10. Duration of Maximum Load
11. Average Load
12. Revolutions per minute
13. Number of Poles
14. Has the machine Interpoles
15. APPROXIMATE DIAMETER of Commutator or Rings
16. Is the mica undercut (i. e. commutator slotted)
17. If collector rings { State number of rings on machine / Is material Iron, Steel, Brass, Bronze or Copper / Are brushes Carbon, graphite or Metal graphite
18. Do brushes run: TRAILING LEADING RADIAL

Information below to be filled out by N. C. Co.

Peripheral Speed of Commutator ..... f. p. m.

Current Density in Brushes ..... amp. per sq. inch

Grade Recommended { For Unslotted Commutator / For Slotted Commutator / For Collector Rings

The Follansbee Brothers Co., Toronto, Ohio, finds this system dependable. Follansbee folks now put all their efforts into sheets and plates. They don't worry about brushes, about styles, grades, shunts or quantities. Nor do we. The data sheets tell all, at once.

This Data Sheet System has been installed—without cost—by our sales engineers in scores of factories, mills, mines and railroads, always to advantage. It will solve *your* brush problems.

*Our sales engineers are eager to serve you.*

# National Pyramid Brushes

*Manufactured and guaranteed by*

NATIONAL CARBON COMPANY, INC., Cleveland, Ohio—San Francisco, Cal.

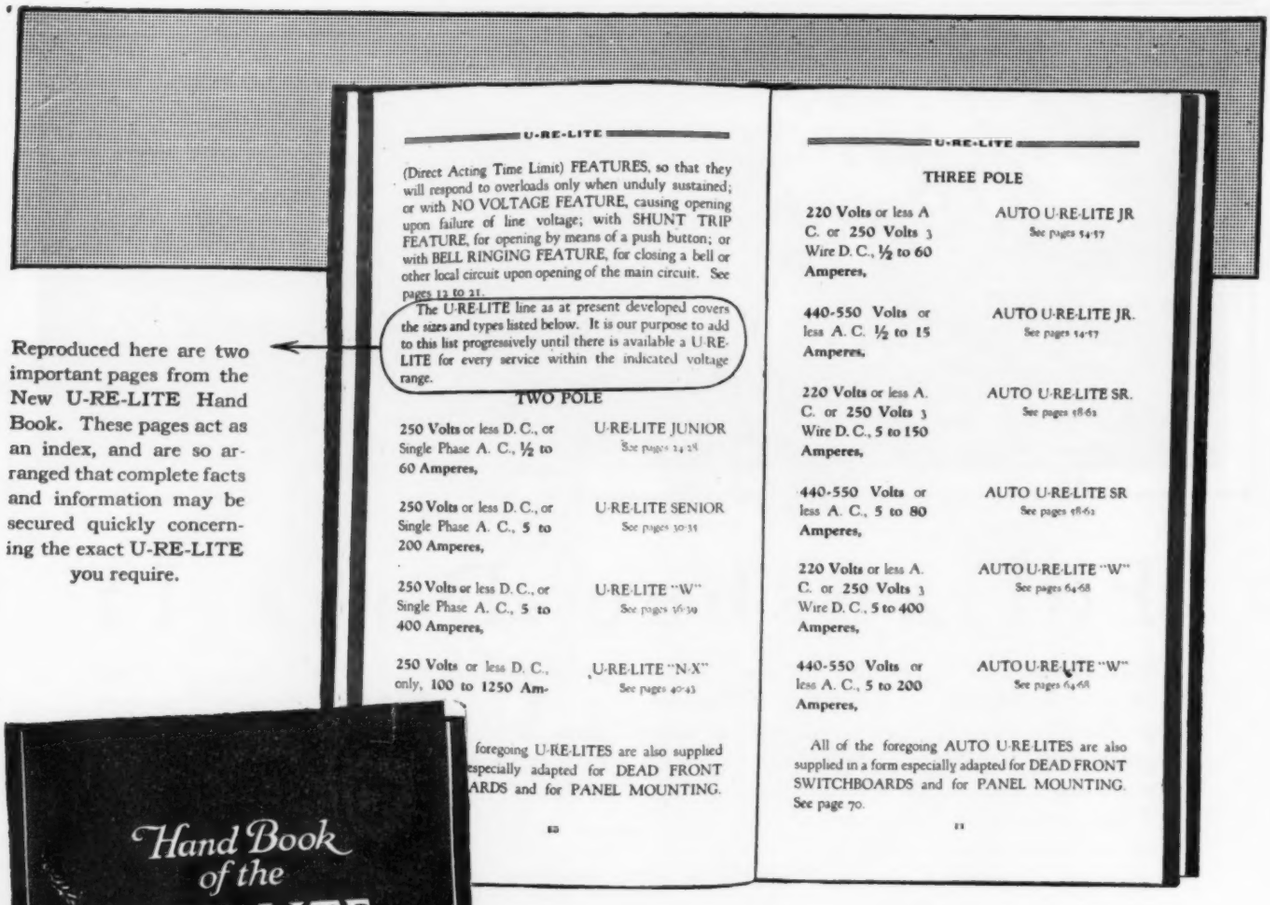
Canadian National Carbon Co., Limited, Toronto, Ontario

*Emergency Service Plants*

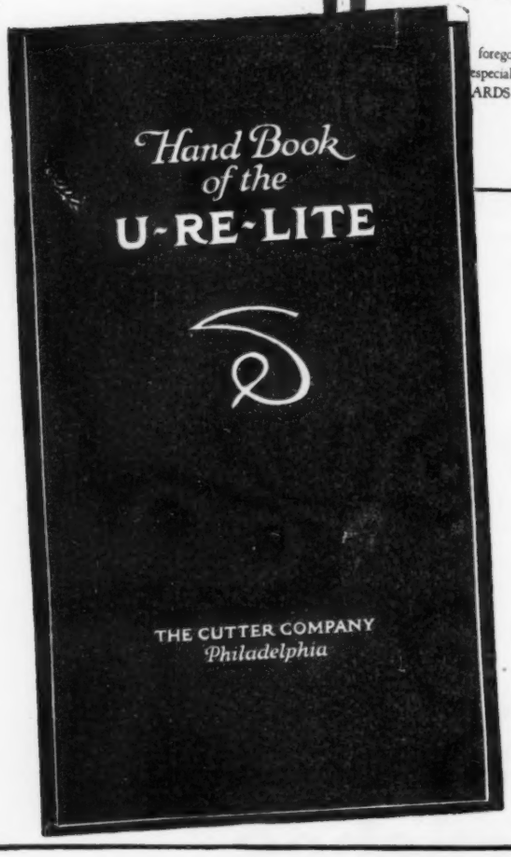
CHICAGO, ILL.
551 West Monroe St.
*Phone,* STAte 6092

PITTSBURGH, PA.
7th Floor, Arrott Power Bldg. No. 3
Barker Place
*Phone,* SMIthfield 0740

NEW YORK, N. Y.
237 East 41st St.
*Phone,* VANderbilt 0425


U-RE-LITE
(Direct Acting Time Limit) FEATURES, so that they will respond to overloads only when unduly sustained; or with NO VOLTAGE FEATURE, causing opening upon failure of line voltage; with SHUNT TRIP FEATURE, for opening by means of a push button; or with BELL RINGING FEATURE, for closing a bell or other local circuit upon opening of the main circuit. See pages 12 to 21.
The U-RE-LITE line as at present developed covers the sizes and types listed below. It is our purpose to add to this list progressively until there is available a U-RE-LITE for every service within the indicated voltage range.
TWO POLE
250 Volts or less D. C., or Single Phase A. C., ½ to 60 Amperes, U-RE-LITE JUNIOR See pages 24-25
250 Volts or less D. C., or Single Phase A. C., 5 to 200 Amperes, U-RE-LITE SENIOR See pages 30-31
250 Volts or less D. C., or Single Phase A. C., 5 to 400 Amperes, U-RE-LITE "W" See pages 56-59
250 Volts or less D. C., only, 100 to 1250 Am- U-RE-LITE "N-X" See pages 40-43
foregoing U-RE-LITES are also supplied especially adapted for DEAD FRONT ARDS and for PANEL MOUNTING.
10
U-RE-LITE
THREE POLE
220 Volts or less A C. or 250 Volts 3 Wire D. C., ½ to 60 Amperes, AUTO U-RE-LITE JR See pages 14-17
440-550 Volts or less A. C. ½ to 15 Amperes, AUTO U-RE-LITE JR. See pages 14-17
220 Volts or less A. C. or 250 Volts 3 Wire D. C., 5 to 150 Amperes, AUTO U-RE-LITE SR. See pages 58-62
440-550 Volts or less A. C., 5 to 80 Amperes, AUTO U-RE-LITE SR See pages 58-62
220 Volts or less A. C. or 250 Volts 3 Wire D. C., 5 to 400 Amperes, AUTO U-RE-LITE "W" See pages 64-68
440-550 Volts or less A. C., 5 to 200 Amperes, AUTO U-RE-LITE "W" See pages 64-68
All of the foregoing AUTO U-RE-LITES are also supplied in a form especially adapted for DEAD FRONT SWITCHBOARDS and for PANEL MOUNTING. See page 70.
11

Reproduced here are two important pages from the New U-RE-LITE Hand Book. These pages act as an index, and are so arranged that complete facts and information may be secured quickly concerning the exact U-RE-LITE you require.




The U-RE-LITE is primarily an appliance for the protection from overloading electric motors and power or lighting circuits. It does this by automatically opening the circuit in the event of excessive current flow. It is, in a word, an electric safety valve. It does what fused switches are intended to do, but accomplishes this end without attendant expense. When the U-RE-LITE is opened by an overload, it does not require the insertion of renewal parts, but by a twist of the wrist may be instantly reset.

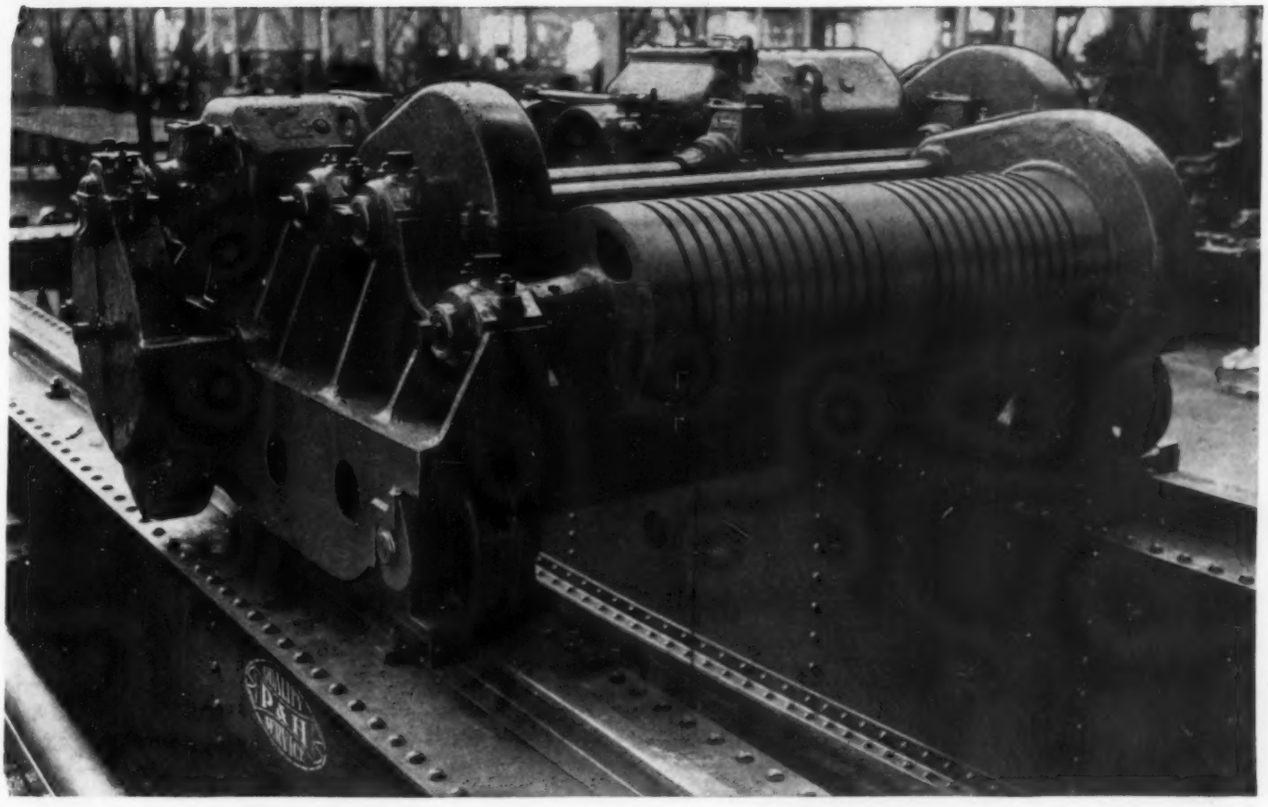
*SEND FOR THIS UNUSUAL BOOK—*
*IT WILL BE SENT FREE*

The New Hand Book of the complete U-RE-LITE line is just off the press. Contains valuable and useful data, facts and figures on the various sizes and types of the famous U-RE-LITE. Bound in boards; size 5x9¼ inches; 96 pages; illustrating the U-RE-LITE, and half-tone pictures of installations, also detailed outline drawings.

THE CUTTER COMPANY
Philadelphia

The CUTTER COMPANY
ESTABLISHED 1888 PHILADELPHIA
1819 HAMILTON STREET

U-RE-LITE, JR.



P & H Type HH 5-ton 44-ft. Span High Speed Crane for Standard Sanitary Co. Foundry, Pittsburgh.

# 104 Lifts Per Hour

THE new P & H Electric Traveling Crane going into the foundry of the Standard Sanitary Company is designed to provide service averaging 104 lifts per hour.

Because of this strenuous duty, chains instead of cables are used—with other parts equally strong to give the usual P & H low cost, long life service.

Since the first three-motor electric traveling crane was built—in the P & H shops 30 years ago—there has always been one big outstanding feature—Dependability. And this applied to both the product and the company. P & H Cranes and Hoists—(over 7,300 in use)—stand up under the most severe and continuous service, whether in steel plant, foundry, railroad shop or other industrial plant.

P & H quality of design and construction—the care in selection of all materials—such extra efforts as the rerolling of all plates in our plant—our "renewal from stock" service—and standardization—insure the added service and dependability that you get when you buy P & H Cranes.

***Crane and Hoist Division***

**PAWLING & HARNISCHFEGER CO.**

**Established in 1884**

**3855 National Avenue, Milwaukee, Wis.**

*New York*
*Atlanta*
*Detroit*
*Kansas City*
*Chicago*
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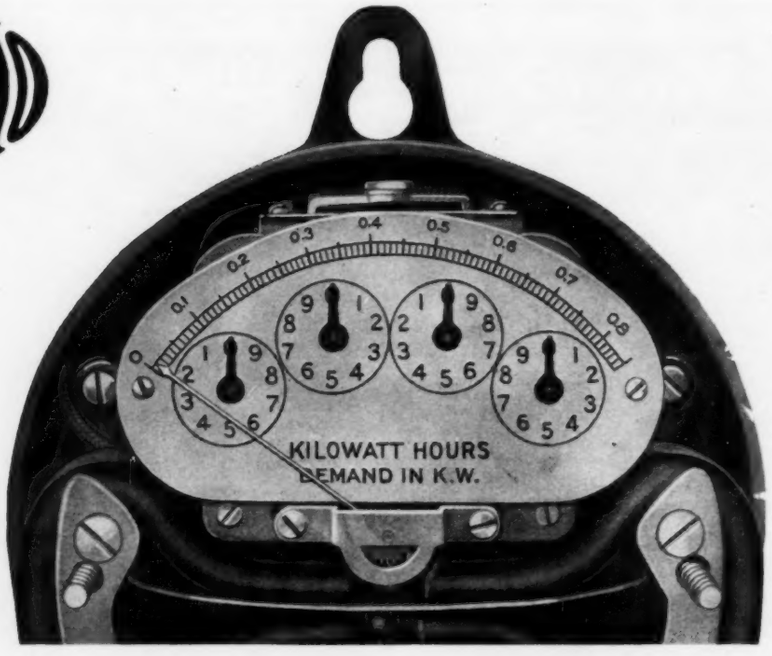
**P&H CRANES and HOISTS**

SANGAMO




# Do not estimate maximum demand—*measure it*

## *It's the cheaper and the only equitable way*

ESTIMATING a customer's probable maximum demand is hardly any fairer than estimating his probable monthly energy requirements and doing without watthour meters. Periodic estimates of customers' demands are expensive and inaccurate and do not permit of ready adjustment of rates if a customer's demand increases or decreases. The consumer is seldom satisfied with the rate he gets for he knows that the estimate of his demand is but little better than a mere guess. The only equitable basis for making demand charges is to determine accurately the *actual* maximum demand that has occurred between regular monthly meter readings.

This is exactly what the Sangamo Maximum-demand Register permits you to do. It combines in one unit a watthour register, a demand register and a timing device, indicating on a single dial the energy consumption and the maximum demand that has occurred since the last meter reading and resetting.

A high degree of accuracy is obtained in both energy and demand indications as the result of a number of features of which the following are the most important.

Very little torque is required to advance the demand-indicator hand thus placing practically no additional load on the rotating element of the meter.

Constant time intervals—a most important consideration—are insured through the use of a new tpye of motor which operates at a constant synchronous speed despite voltage, friction and temperature variations.

*The use of synchronous motors for this purpose is a Sangamo development.*

No slippage or inoperative periods of appreciable length exist as the drive is positive and the pusher arm is reset almost instantaneously through the release of a spring wound up by the synchronous motor.

You can readily obtain the benefits derived from monthly maximum-demand readings as any Sangamo Type-H Watthour Meter may be easily converted into a combined watthour and demand meter by replacing the standard register with the Sangamo Maximum-demand Register. *Write for details.*

## Sangamo Electric Company

**Springfield, Illinois**

New York Chicago Birmingham San Francisco Los Angeles

# SANGAMO METERS

FOR EVERY ELECTRICAL NEED

SAFETY V·V SWITCHES

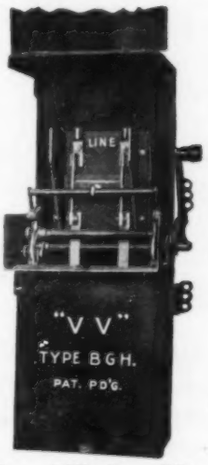
# "THE SUPER SAFETY SWITCH"

## TYPE BGH

Built to Stand Under the Most Severe Conditions

QUICK POSITIVE MAKE INSTANTANEOUS FULL BREAK

All Grounded Parts Shielded by Fibre Barriers
Greater Break Distance and Extra Spacings




Type BGH shows Fibre Barriers in Switch Compartment—sides removed.

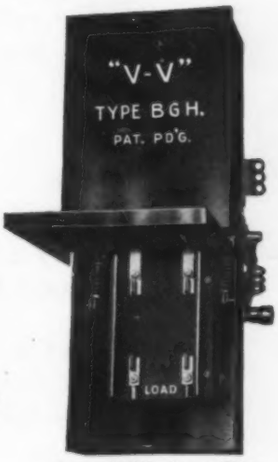
This Switch
Cannot Be Teased
or
Left in Partial Contact

Two-Three-Four
Pole

30-60
100-200
Ampere

250-500
600
Volt

USUAL "V-V" SAFETY FEATURES




Type BGH shows Fibre Barriers in Fuse Compartment.

For Capacities Above 200 up to 1500 Amperes We Embody the Same Insulation Features in our TYPE DFH Which Is Front Operated

***Prices on Application.***

# V. V. FITTINGS COMPANY

New York
50 Church St.

PHILADELPHIA, U. S. A.

Chicago
532 So. Canal St.

Pittsburgh Representative
P. H. Schaum
933 Liberty Ave.

Cleveland Representative
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CONDUIT V·V FITTINGS

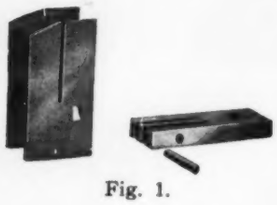


Fig. 1.

Fig. 2.

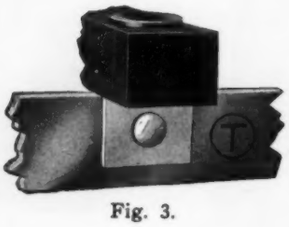


Fig. 3.

Fig. 4.

# *Iron and Steel Electrical Engineers:*

You Iron and Steel Engineers represent probably the first body of men who individually and collectively appreciated that to obtain safety in switches something far more was necessary than just a safety box.

No body of men know better than you the unfortunate position in which safety switches have been placed because of a long drawn propaganda by salesmen and press eulogizing the safety box which keeps the operator away from the live parts of the switch. Such propaganda paid no attention whatever to the first necessity of safety in switches—namely the type of switch in the box that is to do the work.

From the beginning until now, there are few manufacturers and fewer contractors and engineers who pay enough attention to the construction of the knife switch proper, thinking as they do that safety switches mean a safety box surrounding most any kind of a switch.

Even the Underwriters in classifying safety switches speak of Class A, Class B, Class C or even Class AA in terms of boxes only—disregarding the switch entirely—an A box may contain the cheapest switch imaginable. One safe switch for industrial use is the Trumbull Type A manufactured for nearly twenty-five years. The Trumbull type A switch is machine made—built-up, most rigidly constructed and **quick-make** and **quick-break.** It will stand up under use and abuse.

***The Illustrations Show***

**Figure 1**—Foot-block and the pin that fastens the blades to the foot-block after it has been sweated.

**Figure 2**—Shows contact jaw complete.

**Figure 3**—Shows method of fastening the blade to the fibre cross-bar, making a unit of the blade and crossbar.

**Figure 4**—Shows long and strong quick make quick break spring that at no time is worked more than 50 per cent of its capacity.

## The Trumbull Electric Mfg. Company

114 Liberty St., New York City
595 Mission St., San Francisco, Cal.

**Plainville, Conn.**

2001 W. Pershing Rd., Chicago, Ill.
Boston Philadelphia Atlanta

# "BENCO"

## *Weather-Proof Socket for Heavy-Duty Industrial Use*

Bencos are the favorite general service sockets around industrial plants. Exceptionally adaptable to the severe requirements of mills, foundries and other departments of the metal-working industry.

They have a highly insulated rugged interior and a strong metal casing. Type S Reflectors, including Bowl, RLM Dome, Shallow Bowl and Angle, attach directly to Benco Sockets.

NEW PRICES— Several numbers of the Benco Weather-Proof Sockets have recently been specially priced, owing to large production enabling us to affect savings in cost. Write our nearest office for new bulletin.

**Benjamin Electric Mfg. Co.**

**847 W. Jackson Blvd., Chicago**

**247 W. 17th Street, New York**

**580 Howard Street, San Francisco**

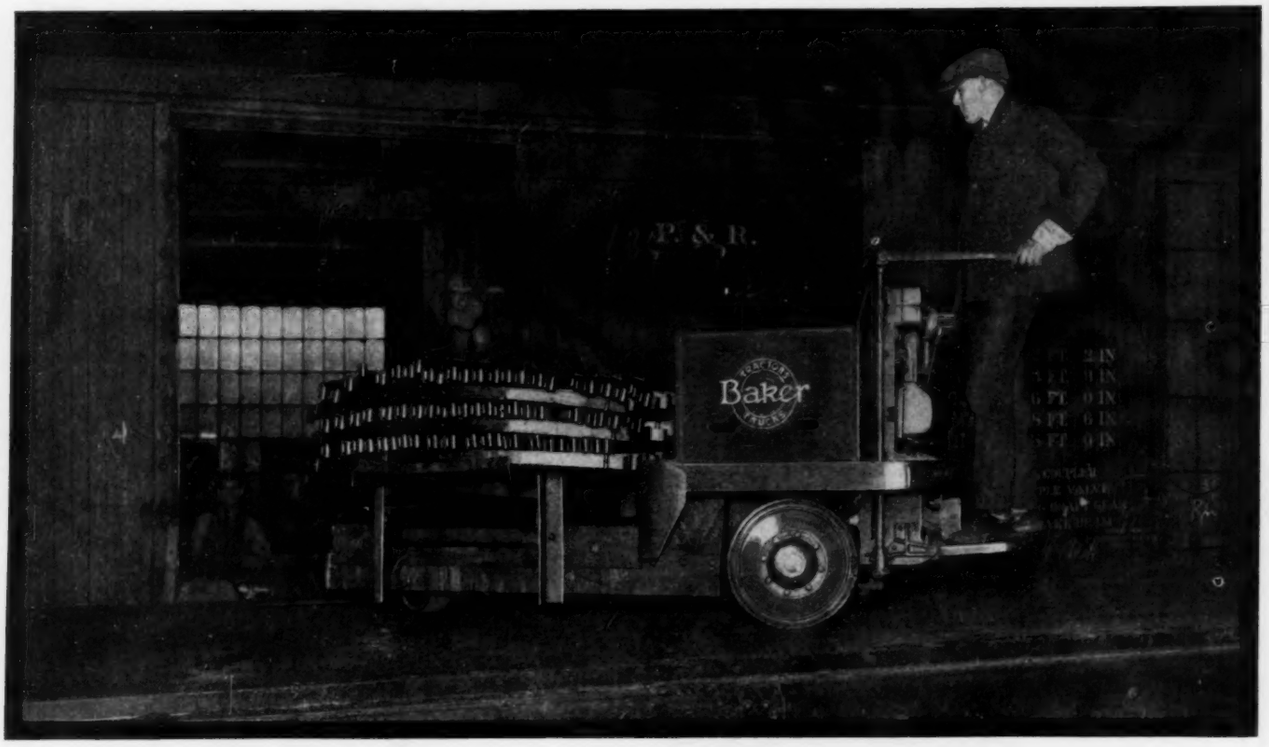
**BENJAMIN**

Makers of Things More Useful

**Keyless. Porcelain interior. Tapped for ½-inch and ⅜-inch Iron Pipe Connection. Casings are of Aluminum, Copper or Brass. Finished in Polished Aluminum, Brushed Brass or Natural Copper.**

**Keyless. Porcelain interior. Brushed for Drop Cord up to ½-inch diameter. With strain relief effective on 16-gauge and larger conductors. Casings are of Aluminum, Copper or Brass. Finished in Polished Aluminum, Brushed Brass or Natural Copper.**

**Pull Chain. The "inner pull" is a big feature. Weather-proof. Chain action unobstructed. Molded Composition interior and Benjamin Lamp Grip. Tapped for ½-inch and ⅜-inch pipe connection. Casings are of Aluminum, Copper or Brass. Finished in Polished Aluminum, Brushed Brass or Natural Copper.**




# "Only four months old, but we're already money ahead"

THAT'S the way officials of the Detroit Steel Products Company felt about the economies effected by their Baker Elevating Trucks at the end of only four months service.

Here's their report on the results secured from each truck in handling automobile springs and material in process with these labor savers:

| | |
|---|---|
| Maximum tonnage per 9½ hour day | 381 tons |
| Number of loads | 118 |
| Average weight of load | 3.23 tons |
| Average distance traveled per day | 9 miles |
| Saving in labor | 5 men |

This is just one of many typical instances that show how the industrial tractor or truck pays for itself in the first few months, and why 60% of all Baker sales go to concerns who have demonstrated their value by actual experience

*Baker Industrial Division*

**THE BAKER R & L COMPANY CLEVELAND, OHIO**

## *Fast, Husky and Trackless*

Down the long shop aisle at double walking speed—6,000 pounds on its load platform—up the steep ramp with never a pause in its progress—across shipping platform and into the box car—dropping its load and away again—a single Baker tractor or truck gets away with more work per day than a sizable gang of hand-truckers.

Below is shown one of the heavily loaded Bakers eating up a 9% grade. The approach to the ramp requires a sharp left-hand turn, meaning practically a standing start.

Write for a fully illustrated, explanatory catalog, or ask a Baker engineer to recommend the most efficient type of industrial tractor or truck for your requirements.

**THE BAKER R & L COMPANY**
**Cleveland, Ohio**

ELECTRIC TRACTORS AND TRUCKS

TRADE-MARK REG. U.S. PAT. OFF.

# Baker

INDUSTRIES using electrical energy save 80% annually in fuse maintenance costs by installing Economy Renewable Fuses in the place of "one-time" fuses.

The famous Economy "Drop Out" Renewal Link—the least expensive and the only portion of the fuse destroyed in operation—makes this saving possible.

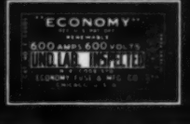
Check up your fuse costs.

*For Sale by All Leading Electrical Jobbers and Dealers*

ECONOMY FUSE & MFG. COMPANY
Chicago, U. S. A.

Economy Fuses were the first line using an inexpensive bare renewal link for restoring a blown fuse to its original efficency to be Approved in All Capacities by the Underwriters' Laboratories.

# ECONOMY *renewable* FUSES



# FLOODLIGHTS

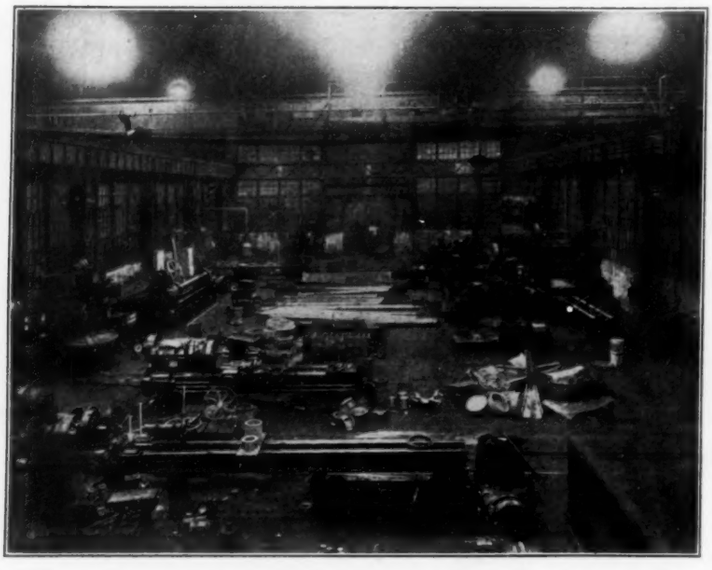
## TYPE RLS

### CEILING TYPE FLOODLIGHT

UNIFORM DISTRIBUTION

SHADOWS ELIMINATED

Type RLS—Suspension Mounting



Machine Shop—Floodlight Installation

**Gas and Moisture Proof**

**Resist the Action of Corroding Vapors**

For use in steel mills, roundhouses, on construction work, or wherever similar conditions exist.

Listed and described in Bulletin 306

**CROUSE-HINDS COMPANY**

SYRACUSE, N. Y., U. S. A.

SALES OFFICES

NEW YORK BOSTON CHICAGO

PHILADELPHIA DETROIT ST. LOUIS MINNEAPOLIS

CINCINNATI SAN FRANCISCO

CH 130

# CROUSE-HINDS

KEYSTONE ACCOMPLISHMENTS

*No. 2 of a series*

In the plant of an eastern concern eight Venango Cups feed 25 lbs. of Keystone Grease No. 3 Velox to the bearings of two pulverizers in three months, which is about 84 working days. No. 3 Velox costs 25 cents a lb., making a total cost for three months of $6.25.

Compare this figure with $210.00, the price they paid when using ordinary "cheap" grease. 25 lbs. were consumed *daily* in lubricating these two pulverizers with ordinary grease. The cost of such grease being approximately 10 cents per lb.; a total cost for three months of $210.00

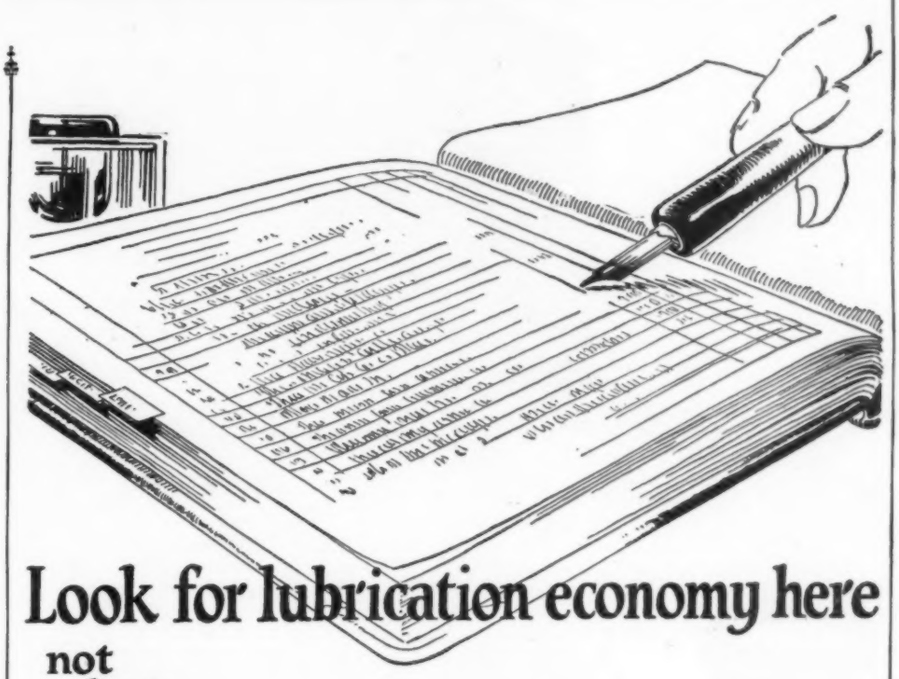
Now, by using Keystone Grease they no longer have the monthly cost of replacing from four to five bearings. Nor are they compelled to keep a laborer in the Pulverizer Room all day long to do nothing but fill up and screw down the hand compression cups, as was necessary when "cheap" grease was used. Both costs are eliminated through the use of Keystone Grease and Keystone Systems of Lubrication.

Cold facts, these. Facts that may set you to thinking of just what lubrication costs in your plant.

It is just this matter that we would like to talk with you about. For Keystone's forty years' experience in cutting lubrication costs embraces all industry, all types of machines.

To insure talking to the Keystone Sales Engineer when he calls, we suggest that the executive responsible for specifying the lubricant to be used write us expressing his desire.

KEYSTONE GREASE



# Look for lubrication economy here

not here

Lubrication costs you less if you use a pure petroleum lubricant, like Keystone Grease. It not only cuts lubrication costs to the core, but better lubrication is secured, more power released for increased production, costly repairs and expensive shutdowns are eliminated.

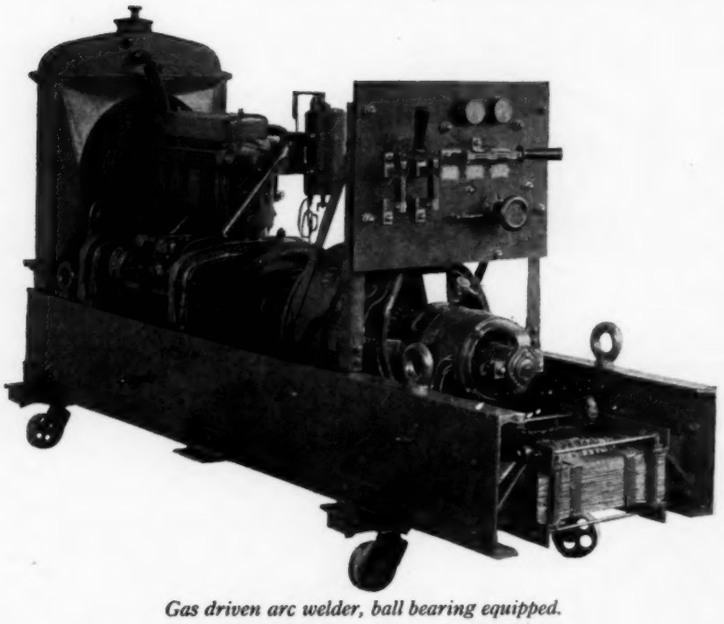
Keystone Grease is as honest a lubricant as can be made, and though it may cost a few cents more in the container—for it is not a cheap grease—it costs less in the bearings. THE KEYSTONE LUBRICATING CO., *Est. 1884,* PHILADELPHIA, PA., *at 21st & Clearfield Streets.*

# Keystone Grease

***The Master Lubricant***

For Every Industry

*Reg. U. S. Pat. Off.*



*Gas driven arc welder, ball bearing equipped.*

Double-acting thrust bearing, flat seats (grooved races) 2100-F Series

Single-acting thrust bearing, flat seats (grooved races) 1100-F Series

Single-acting, self-aligning thrust bearing 1100 Series

Single-acting, self-aligning thrust bearing, leveling washer. 1100-U Series

Double-acting, self-aligning thrust bearing, leveling washers 2100-U Series

# Advantages of Strom Ball Bearings in Electric Motors

THERE are many advantages — advantages of uninterrupted service, running and starting facility, economy of upkeep, added life to the motor.

**Here are the outstanding advantages Strom Ball Bearings offer you:**

1—Freedom from insulation troubles caused by oil leaks. Housings can be designed to retain lubricant, preventing its escape on to the insulation.

2—Saves service interruptions.

3—Uniform air gap between armature and coil, as there is practically no wear on ball bearings.

4—Reduced friction minimizes starting and running resistance. Starting resistance is so light that it is no greater than running resistance.

5—Strom Ball Bearings take end thrust as well as radial load. This feature also reduces vibration and increases life of motor.

6—More compact design of electric motor. The space required for ball bearings is smaller.

Many more exclusive features could be pointed out. But these are the outstanding advantages insured by Strom Ball Bearings.

We make Strom Ball Bearings in a wide range of sizes and types for practically any installation. Our engineers will design special mountings if necessary and advise on the best type of bearings for your needs. Consult them without obligation.

Single-row deep-groove Standard type, radial bearing

Double-row, deep-groove Standard type, radial bearing

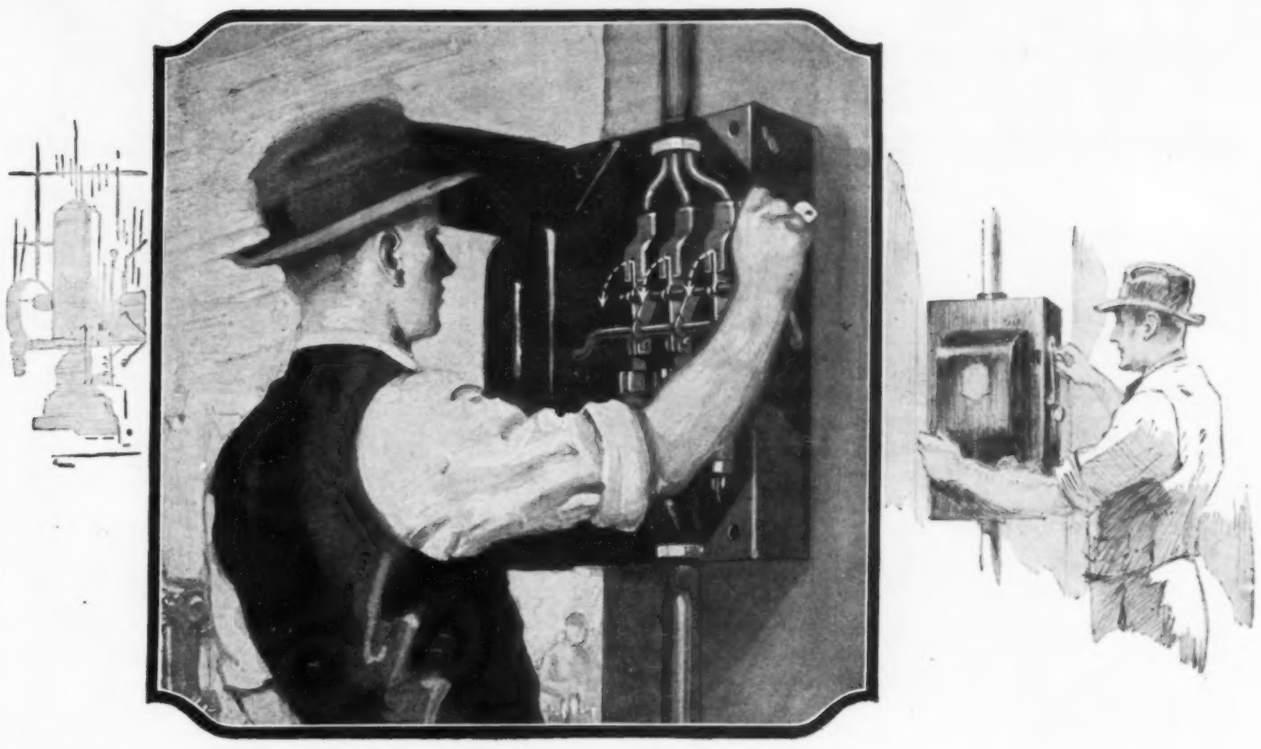
Angular contact bearing, combination radial and thrust

Double-row, maximum type, radial bearing

Single-row, maximum type, radial bearing

Strom BALL BEARINGS

**STROM BALL BEARING MFG. CO.**
Formerly U. S. Ball Bearing Mfg. Co.
**4594 Palmer Street, Chicago, Ill.**



# Strength and Simplicity

## *—in the Square D quick-make, quick-break mechanism.*

The Square D Quick-make and Quick-break mechanism is a feature, even in this switch, which is distinguished by so many advantages.

It is ingenious, simple, rugged, and positive in action. It is quick acting. The blades snap sharply into contact, or sharply disengage.

The Square D switch cannot be left partially "on" or partially "off". Contact is always positive. Arcing is minimized.

The mechanism is enclosed inside the switch box, completely protected from dust and dirt, or possible tampering.

Advantages like these are the things that make the Square D safer and more efficient to use, less costly to maintain, and more satisfactory in every way.

A representative will gladly point out the many other reasons why it is the logical switch to stock or install. Write to the factory, or to any branch office.

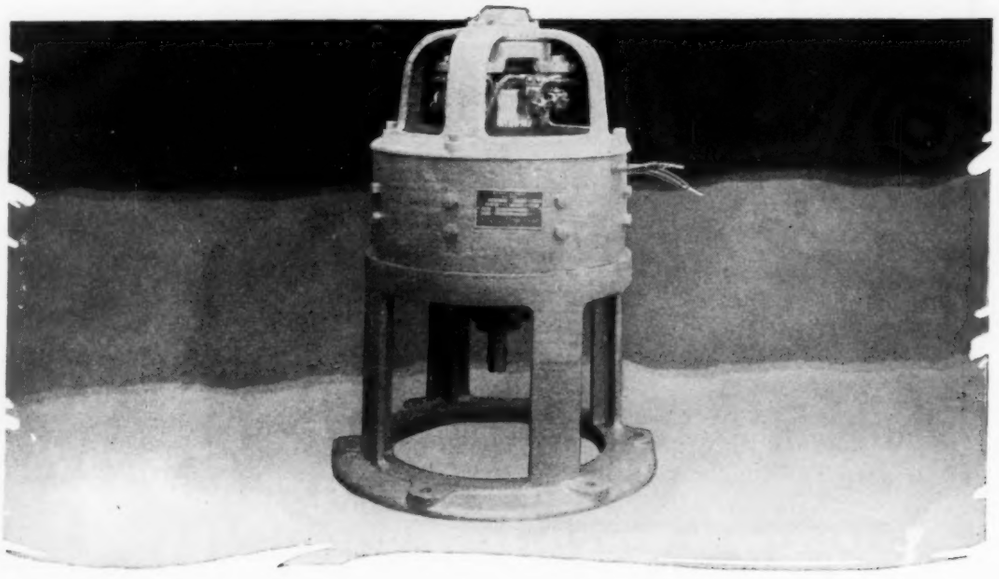
*This shield distinguishes the Square D switch from its imitations. Look for it before you buy.*

**SQUARE D COMPANY, DETROIT, U.S.A.**
**FACTORIES AT: DETROIT, MICH., PERU, IND.**
BRANCH OFFICES: Boston, Buffalo, Chicago, New York, Pittsburgh, St. Louis, Philadelphia, Cincinnati, Milwaukee, Atlanta, Cleveland, San Francisco, Los Angeles, Syracuse, Kansas City, New Orleans, Baltimore, Columbus, Minneapolis, Indianapolis
**SQUARE D COMPANY, CANADA, LTD., WALKERVILLE, ONT.**
BRANCH OFFICES: Toronto, Montreal

(61)

# SQUARE D
# Safety Switch

SKF



# Ball Bearings Eliminate Lubricant Troubles—Prevent Wear on Vertical Motors

WHEN plain bearings are used in vertical motors, trouble frequently arises due to the difficulty of keeping the bearings properly lubricated. If the oil film fails friction and wear result in the ultimate destruction of the bearing.

Lubrication troubles are ended when armatures of vertical motors are mounted on Skayef Self-Aligning Ball Bearings. They require minimum maintenance and compensate automatically for shaft deflections without pinching, binding or wear of the shaft, housing or bearing. Sealed housings effectively prevent the entrance of water or dirt, a desirable feature where vertical motors are installed in wet and dirty places such as pump pits, subbasements and mines.

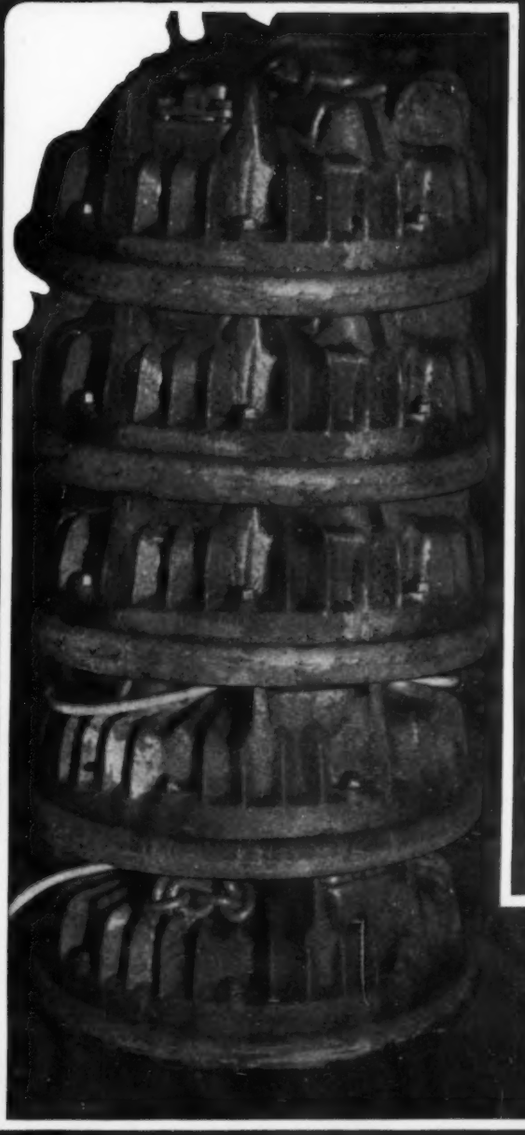
**THE SKAYEF BALL BEARING COMPANY**

Supervised by SKF INDUSTRIES, INC., 165 Broadway, New York City

1219

*Normal View* *Deflected View*

# New Design Ready to Ship



This New Design of Magnet has much greater lifting power and is more efficient in all ways.

Get in touch with nearest office given below.

**THE ELECTRIC CONTROLLER & MFG. CO.**

**CLEVELAND, OHIO**

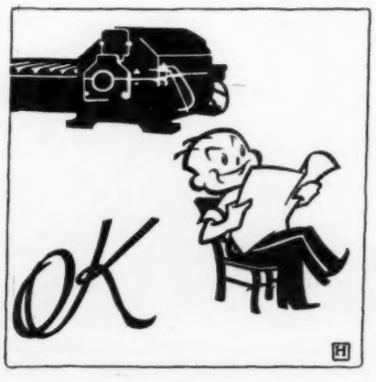
**BIRMINGHAM** - BROWN-MARX BLDG.
**CHICAGO** - CONWAY BLDG.
**CINCINNATI** - FIRST NATIONAL BANK BLDG.
**DENVER** - 3535 WALNUT ST.
**DETROIT** - DIME BANK BLDG.
**LOS ANGELES** - O.E. THOMAS CO. AMERICAN BANK BLDG.
**NEW YORK** - 50 CHURCH ST.
**PHILADELPHIA** - WITHERSPOON BLDG.
**PITTSBURGH** - OLIVER BLDG.
**SAN FRANCISCO** - CALL BUILDING
**SEATTLE** - 524 1ST AVE. SOUTH
**TORONTO** - TRADERS BANK BLDG.

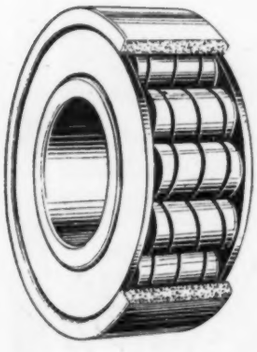
# When An Armature Coil Burns Out

One of your key position motors! Production held up. No time to lose—

Don't worry if the motor is Hyatt equipped. Just hoist the damaged armature out of the motor frame—

Bring on your spare armature. Transfer the Hyatt bearings and housings as a unit by hand (no tools) to the shaft of the spare—



Drop the spare into place and you're all set!

HYATT ROLLER BEARING COMPANY
NEWARK, NEW JERSEY

HYATT ROLLER BEARINGS FOR ELECTRIC MOTORS

# "We can cut our fuse consumption 50% by using your product"

RADIO — THE HOT WATER RADIATOR WITH THE OPEN FIRE PLACE FOR THE HOUSE WITHOUT A CELLAR — HOT WATER HEAT IN EVERY ROOM

CENTRAL RADIATOR COMPANY

LANSDALE, PA.

RADEX — SELF-FEEDING STEAM AND WATER BOILERS FOR THE SMALL HOUSE OPEN DRAFT NON-CONSUMING — AT A POPULAR PRICE

January 15, 1924.

Buesmann Mfg. Company,
St. Louis, Mo.

Gentlemen:

We have recently signed a contract to use the Buss Fuses exclusively at our Plant for the year 1924. Our reason for doing this was due to the fact that during the past year we procured a quantity of these fuses from our Electric Light Commission, Lansdale, and found them so much more serviceable and satisfactory, both to the quick renewal and the long life of the fuses, and we are under the impression that we can cut our fuse consumption 50% by using your product.

We trust that you will arrange with your local representative to have a full line of your fuses in stock at all times so that they can be procured in the quantities as desired by us.

Very truly yours,

CENTRAL RADIATOR COMPANY.

HFQ:SC

MANAGER.

**Poor contact is the chief cause of fuse destruction.**

**In the BUSS Renewable Fuse the extreme simplicity of design not only permits quick, easy renewal, but prevents poor contact due to faulty renewal.**

INSERT THE LINK
closed end eliminates one washer
PUT ON CAP
full length cap gives large gripping surface
SLIP WASHER ON
washer is held by bent end of link
PUT ON SECOND CAP
(note projection and recess)
and
THE FUSE IS READY FOR SERVICE

**A sample will convince you**

(18SE 8-24)

# BUSS FUSES

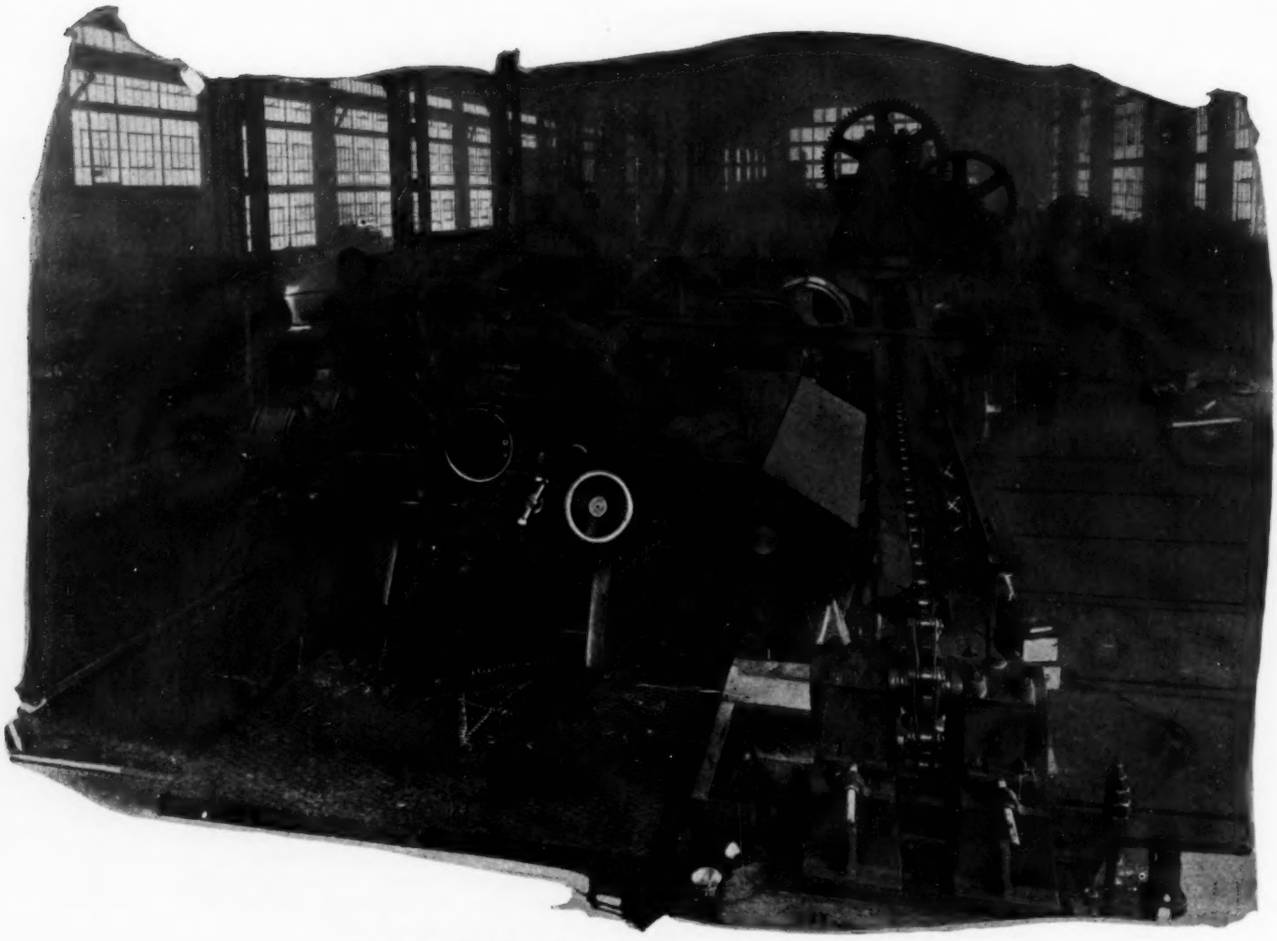
## APPROVED IN ALL TYPES AND SIZES

TRADE BussFuses ELECTRICITY'S SAFETY VALVE MARK REG. U.S. PAT. OFF.

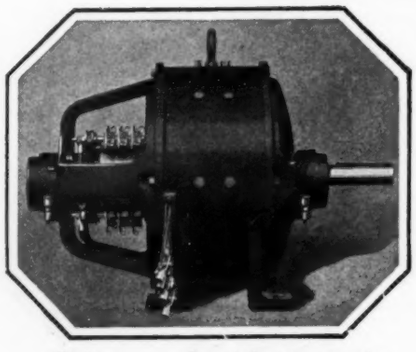
"ELECTRICITY'S SAFETY VALVE" MEANS ON

BUSSMANN MANUFACTURING CO.
3819 No. Twenty-Third St., St. Louis, Mo.
Without obligation, send me for examination sample 30 ampere, 250 volt Ferrule Contact Type BUSS Renewable Fuse.

Name _____ Position _____
Company _____
Street _____
City _____ State _____



Treadwell Special Tube Cutting-Off Machine equipped with 4 Type T Heavy Duty Reliance Motors



*Eight years of satisfactory service on hard jobs in steel and tube mills have proved that Type T Reliance Motors are entitled to be termed "heavy duty" motors.*

# Helping To Cut Them Fast

Every minute on this machine means one more 14″ tube cut off. Four Type T Reliance Motors play a part in maintaining this production pace.

Only rugged motors that can be depended upon for continuous hard service will do for important work like this. It is on such jobs that Type T motors are proving their ability to give the results demanded by steel mill engineers.

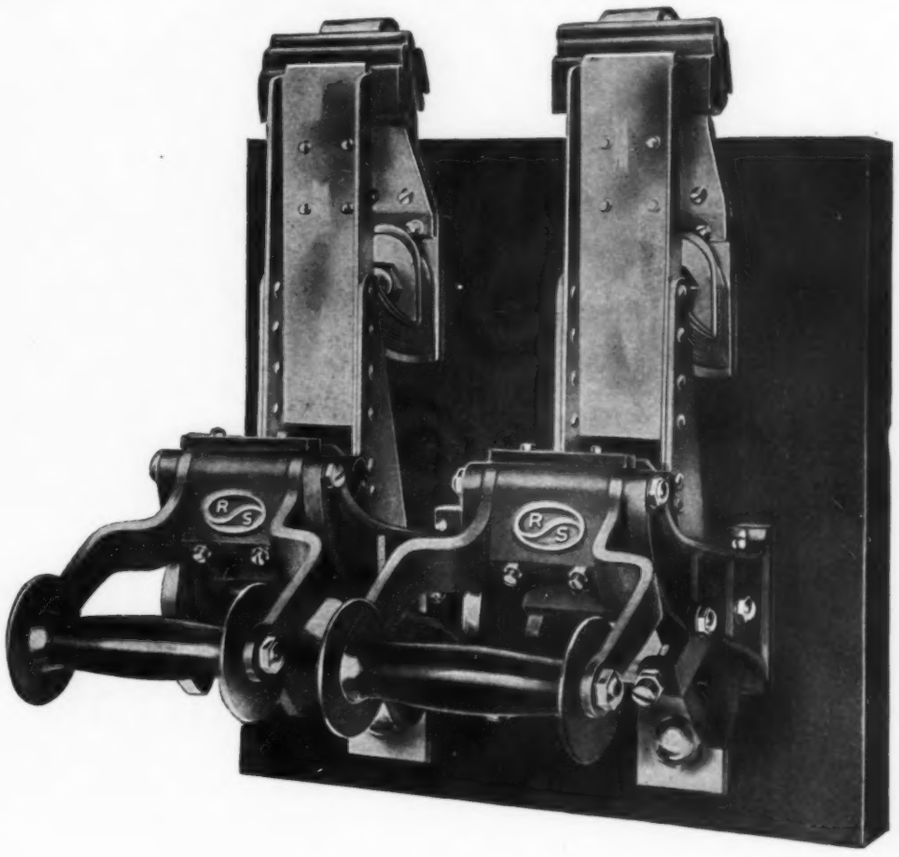
Complete evidence that Type T motors are designed and built to insure continuous service and the good results expected from expensive machines, is given in Bulletin 2014.

## Reliance Electric & Engineering Company

1080 Ivanhoe Road, Cleveland, Ohio

Branches: Boston New York Philadelphia Pittsburgh Cincinnati Detroit Chicago Birmingham, Ala.

Type T Heavy Duty RELIANCE MOTORS Direct Current



# The Functions of a Circuit Breaker

FIRST—To carry its rated current continuously without excessive heating.
SECOND—To open its circuit in the smallest possible fraction of a second and to be ready to repeat the performance day in and day out.

## The Roller-Smith Standard Type Circuit Breaker

has been proved to meet these requirements even under the most severe and exacting conditions. It is so liberally proportioned that it "keeps cool." It is so ruggedly built that it will give CONTINUOUSLY GOOD SERVICE over a GREATER LENGTH OF TIME with LESS ATTENTION than any other breaker. We believe that is the kind of a circuit breaker MOST people want. HOW ABOUT YOU?

ROLLER-SMITH COMPANY
Electrical Instruments, Meters and Circuit Breakers

*Main Office*
2131 Woolworth Bldg.
NEW YORK

*Works*
Bethlehem, Penna.

*Offices in Principal Cities in United States and Canada*

*For your convenience*

CLIP THIS SLIP

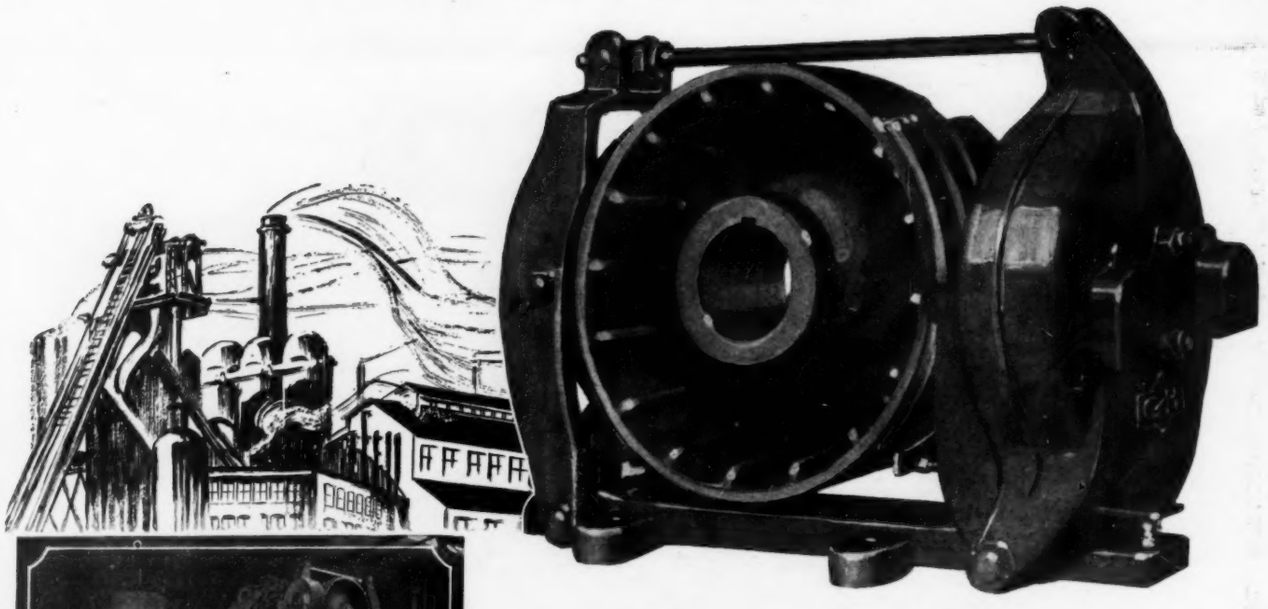
Request for Roller-Smith Bulletin AK-530

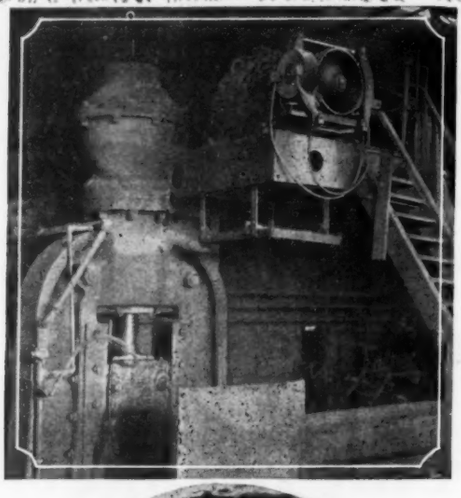
Name .....

Company .....

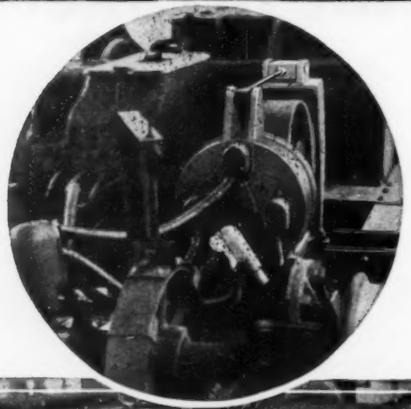
Address .....

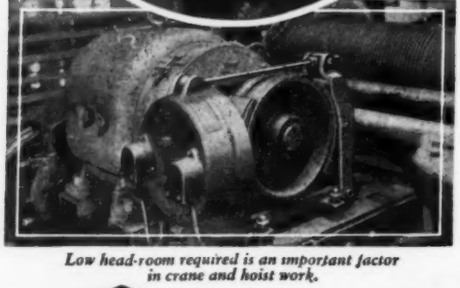
City ..... State .....





*Above, C-H Type M Brakes on screw-downs provide the snappy action desired and withstand the severe frequent service.*





*Low head-room required is an important factor in crane and hoist work.*

# Squatty, Rugged, Simple

There isn't a frill on the Cutler-Hammer Brakes—the power, long life and quick action are a direct result of the remarkable simplicity—a distinct Cutler-Hammer achievement.

The magnet action is direct with the operating magnet enclosed in a husky weatherproof, ironclad housing. This direct action eliminates toggles, bell cranks, levers.

The overall height is practically no greater than the brake wheel itself.

The short magnet stroke is the reason for the quick, quiet action which eliminates shock and hammer and the resulting wear.

## *Thousands in Use*

On performance alone, there has developed a demand which has grown steadily until today there are thousands in use and an increasing monthly demand.

Bulletin 850 contains the complete details. Copy on request.

**THE CUTLER-HAMMER MFG. CO.**

*Magnet and Clutch Department*
*Works:* MILWAUKEE *and* NEW YORK
*Offices and Agents in Principal Cities*
*Northern Electric Co., Ltd., Can.*

C-H CUTLER-HAMMER

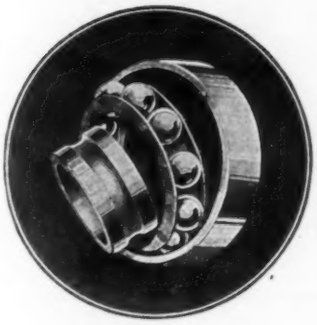
# ELECTRIC BRAKES

# PRECISION BEARINGS

## Make Good Machines Better

They strengthen what are often the weak parts in the structure—the shaft and spindle bearings. They minimize a prolific cause of trouble—friction and wear in the bearings. They reduce power consumption and oil consumption. They contribute materially to longer life, better performance, lower upkeep, increased and improved production.

### "NORMA" PRECISION BALL BEARINGS

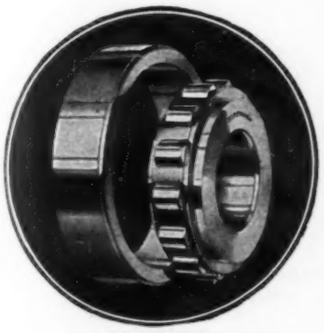


OPEN TYPE

Experience has proved the preeminent superiority of these high precision units under conditions where maximum serviceability and freedom from vibration under high-speed operation are essential. They have all the load-carrying capacity of any ball bearing, combined with a speed-ability which no other ball bearings have. For years past, they have been the standard bearings in tens of thousands of high-speed machines operating under severe conditions. They are increasingly in demand for high-speed grinders and drills, precision measuring devices, electric tools, fractional hp. motors and small generators.

CLOSED TYPE

### HOFFMANN PRECISION ROLLER BEARINGS



STANDARD

Designed for conditions involving heavy loads, hard service, shock, jar and vibration, these high-precision, heavy-duty units have proved their entire success. They have all the speed-ability of the best ball bearings, with a much greater steady load-carrying capacity than any ball bearing and with a temporary overload capacity, as under shocks or in starting, which no ball bearing has. They are made in both standard and self-aligning types—some of the latter being wholly enclosed, lubricant packed and dust-and-moisture-proof. They are the preeminent bearings for high-duty, heavy-duty machines from which the utmost is demanded.

ENCLOSED SELF-ALIGNING

**"NORMA" engineers will welcome an opportunity to work with yours in applying these high-precision bearings to the machines you make or use.**

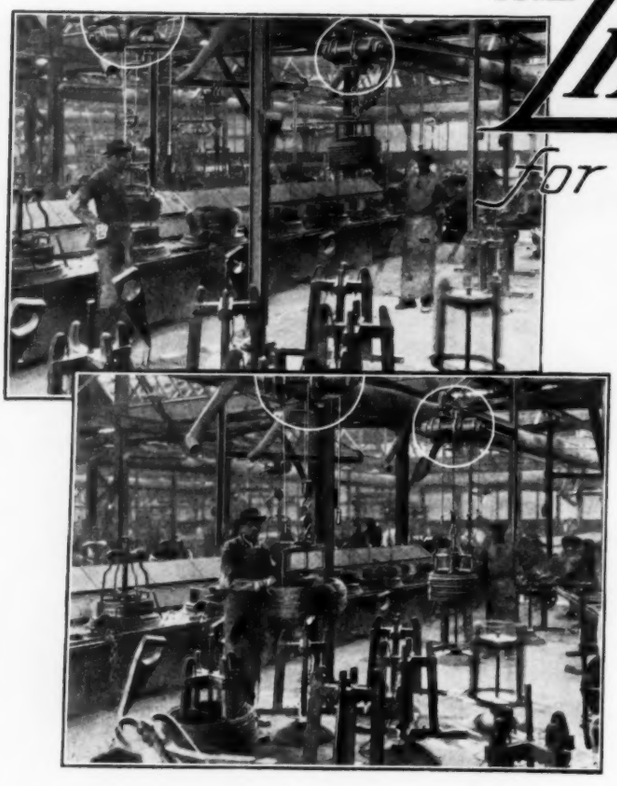
## THE NORMA COMPANY OF AMERICA

Anable Avenue Long Island City New York

BALL, ROLLER AND THRUST BEARINGS

THE SHEPARD ELECTRIC LIFT ABOUT JR.

for 500 pound loads



## Announcing a new Shepard Hoist for handling 500 pound loads

The LiftAbout Jr., a small edition of the well-known Lift-About, meets the demands of manufacturers everywhere for an economical method of handling loads of a few hundred pounds. Low in cost and dependable in operation, it affords low-cost handling of numerous light capacity loads.

For instance, the LiftAbout Jr. is adequately suited for block-stripping in wire mills. It lifts coil of wire from block and deposits it on reel, speeding up production and decreasing labor costs.

It has the same features of design which have made the LiftAbout and larger Shepard Electric Hoists the most widely used hoists in America.

Write us NOW for complete information on the LiftAbout Jr.

**SHEPARD ELECTRIC CRANE & HOIST COMPANY**

356 Schuyler Ave., Montour Falls, N. Y.

Branches in principal cities.

*Member Electric Hoist Manufacturers' Assn.*

### A few of the uses for the LiftAbout Jr.

Handling nuts and screw machine products.
Handling small rods in steel mills.
Serving crank shaft and axle lathes.
Slasher hoist for cotton mills.
Beam Dyeing hoist for cotton mills.
Handling rolls of cloth in textile mills.
Handling baskets of cans in canning factories.
Operating dumbwaiters.
Block Testing in automobile plants.
Pickling operations in various industries.
Window sash painting.
Handling cases and raw material in knitting mills.
And many others in practically every business and industry.

REG. U.S. PAT. OFF.

SHEPARD ELECTRIC CRANES & HOISTS

# USEFUL INFORMATION

## For the Iron and Steel Engineer

### *Some Nuttall Products He Needs Every Day*

Type A

Type C

Type B

### Flexible Couplings

**Type A—Rubber Buffer Type.** Good for 10 to 1300 H.P., 400 to 2700 r.p.m., 1¼" to 13" shafts, outside diameters range from 5½" to 48".

**Type B—Cast Steel, Spring Type.** Good for 100 to 4875 H.P., 200 to 1150 r.p.m., 3" to 18½" shafts, 13" to 78" outside diameters.

**Type C—Enclosed, Spring Buffer Type.** Good for 85 to 2700 H.P., 440 to 3600 r.p.m., 1½" to 15½" shafts, outside diameters 6½" to 52".

### Our Gear Limits

| Type of Gear | Max. Diam. | Max. Pitch |
|---|---|---|
| Planed Bevel | 192" | 6½" |
| Generated Bevel | 25" | 1½" |
| Cut Spurs | 360" | 6" |
| Planed Spurs | 240" | 6" |
| Generated Spurs | 138" | 1 DP |
| Worm Wheels | 138" | 1 DP |
| Spiral Gears | 138" | 1 DP |
| Helical Gears | 138" | 1 DP |
| Herringbone Gears | 140" | 6" |

*A complete descriptive book, full of valuable data, will be sent free on request.*

A Nuttall Helical Gear Set

R.D. NUTTALL COMPANY
PITTSBURGH PENNSYLVANIA

Philadelphia Office
420 Land Title Bldg.

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2133 Conway Bldg.

Nuttall

# Electrical Engineering and Manufacturing Company

General Offices:

## PITTSBURGH, PA.

We are prepared to furnish your requirements in the following materials and equipment:

"MORGANITE" Carbon-Graphite Metal Brushes.

"ROWAN" Automatic Controllers and Starters.

"SUMET" Bronze and Babbitt Bearing Metals.

"DUTCHESS", Empire or Varnished Cloth and Tape.

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We have a corps of expert engineers, specialists in the above lines, who will be glad to give immediate attention to your inquiries or to see you at your request for consultation regarding applications or equipment. Call or write our nearest office.

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Phone Maine 3257

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907-909 Penn Ave.
Phone Grant 6693-4

# *Purdah*

For centuries the purdah (veil) has been the rule in India society.

No amount of temptation, almost, can make a lady reveal her charms to anyone outside her household.

You have to belong to the family to really see and appreciate a lady's charms.

Commutation is a similarly shrouded affair.

If you use the wrong brushes you get a veiled sort of commutation.

But unless you become one of the Morganite family—you can't get a really close-up view of, and enjoyment from, good commutation.

Don't be tempted by unprescribed brushes.

MORGANITE BRUSH CO., INC.
519 West 38th St., New York City
DISTRICT ENGINEERS AND AGENTS

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J. F. Drummey, 75 Pleasant St., Revere, Mass.

Special Service Sales Co., 202 Russ Bldg., San Francisco, Calif.

Electrical Engineering & Mfg. Co., 607 Mercantile Library Bldg., Cincinnati, Ohio.

Railway & Power Engineering Corp., Ltd., 131 Eastern Ave., Toronto, Ontario, Canada.

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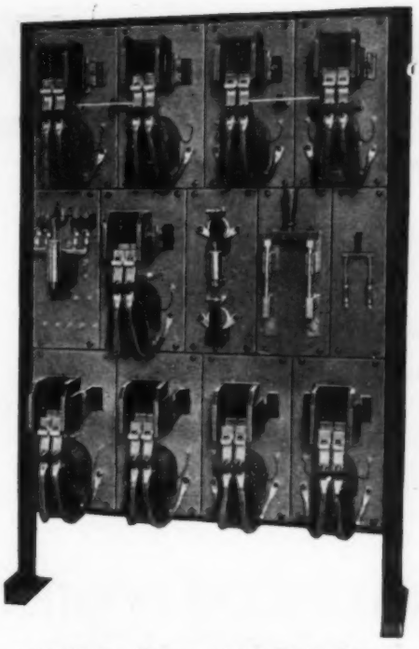


150 H.P. Type 4750 Full Speed Reversing Mill Controller

# Automatic Motor Starters and Controllers

*for*

## Alternating and Direct Current Electric Motors

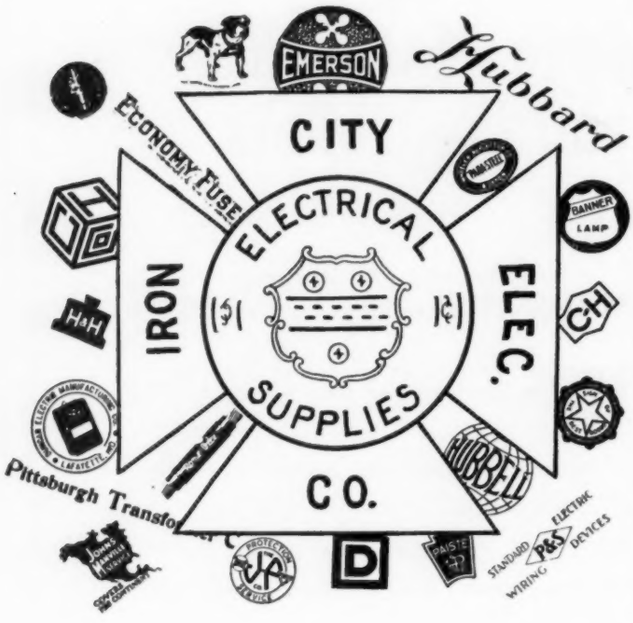
***May we send our nearest representative to see you?***

**ROWAN CONTROL**
THE ROWAN CONTROLLER CO., BALTIMORE, MD.

# Pittsburgh Transformer Company

*Largest Manufacturers of Transformers Exclusively in the United States*

Pittsburgh, Pennsylvania




The Trade Mark

of the

# Iron City Electric Co.

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REPRESENTING

*"The House That Service Built"*

IS BACKED BY A GROUP OF

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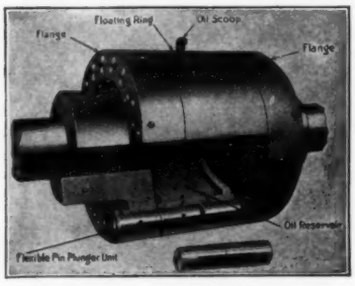
# FRANCKE

FLEXIBLE COUPLINGS

*"They make good machines last longer"*




## ANOTHER IMPROVEMENT

## A little detail brings better results

In the Double Type Francke flexible coupling a floating ring is supported on two sets of flexible pin units which transmit the driving torque first from one flange to the ring, then from the ring to the other flange. The object of this construction is to give the Double Francke a greater capacity for out of center misalignment, such as is desirable for the larger rolling mill drives and on other continuous drives where excessive misalignment may be expected.

A centering device has just been perfected to hold the floating ring central with respect to the two end flanges. This is being supplied with all new double coupling installations. It is also recommended for all present double coupling installations. A conservative estimate indicates that this improvement will make the wearing parts last at least twice as long. Details will be furnished upon request.

# SMITH & SERRELL

Coupling Specialists Since 1912.

64 Washington Street, Newark, N. J.

District Office, Fulton Building, Pittsburgh

1891 — 1924

# MORGAN
## Construction Company
**Worcester, Mass., U.S.A.**

*Designers and Builders of*

**Morgan Continuous Mills**

*for*

**Billets, Sheet Bars, Skelp, Merchant-Bars, Hot-Strip, Rods**

*also*

**Wire Drawing Machines**
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**Re-Heating Furnaces**
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*Our Engineering Department*

is prepared to solve successfully your problems in design or arrangement of plant and equipment from open hearth to finished product

1891 — 1924

*Mogul Reelites are regularly furnished with any desired length of two or three conductor "Super-Service" cable. One inch male-threaded hubs facilitate mounting on brackets or machine frames.*

# A Guardian for Your Power Cords

No longer is it necessary to drag long, tangled lengths of heavy cable around over the floor when portable power machines are moved from place to place. The Mogul Type Reelite has eliminated that.

All of the cord not needed is kept coiled in the steel container of the Reelite, protected, clean and unkinked. It is easily unreeled as the machine is moved to greater distances and automatically re-reeled as the machine is brought closer to the power outlet, thereby saving much time and trouble and freeing the cords from the wear to which they are usually subjected.

The Mogul Type Reelite can easily be attached to any portable machine, or, if desired, it can be mounted at the outlet for extending power to the smaller machines and hand tools.

*There is a type and size of Reelite adapted to every power extension requirement. Let us tell you more about them.*

APPLETON ELECTRIC COMPANY
1717 Wellington Avenue
CHICAGO

**MOGUL TYPE**
# Reelite
REG. U.S. PAT. OFF.

# ALLIANCE CRANES

***Largest Builders of the World's Largest Cranes***

204 of 100 Tons Capacity and Over

STANDARD CRANES

| | | |
|---|---|---|
| 55 | 100 | tons |
| 2 | 115 | tons |
| 42 | 125 | tons |
| 24 | 150 | tons |
| 22 | 175 | tons |
| 2 | 200 | tons |
| 1 | 225 | tons |
| 1 | 250 | tons |
| 3 | 430 | tons |

STRIPPING CRANES

| | | |
|---|---|---|
| 8 | 100 | tons |
| 1 | 125 | tons |
| 19 | 150 | tons |
| 13 | 200 | tons |
| 1 | Single Ram, 320 | tons |

COMBINATION CHARGERS AND STRIPPERS

| | | |
|---|---|---|
| 3 | 100 | tons |
| 3 | 150 | tons |
| 4 | 200 | tons |

ELECTRIC RUMSEY EQUIPMENT

ESTABLISHED 1895

## RUMSEY ELECTRIC COMPANY

***ELECTRIC SUPPLIES and MACHINERY***

1007 Arch St., PHILADELPHIA

FACTORY DIRECT REPRESENTATIVES

***EFFICIENT***
***RELIABLE***
***SERVICE***

HIGH TENSION
ELECTRIC POWER EQUIPMENT CORPORATION ELPEC PHILADELPHIA, PA.
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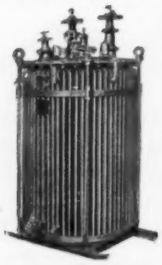
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STORE AND OFFICE BUILDING
WAREHOUSE, 1010 CHERRY ST.

SANGAMO

METERS
SANGAMO
BUILT LIKE A WATCH

"Sirocco"

AMERICAN BLOWER CO.
VENTILATING FANS
AND BLOWERS

C-H
CUTLER-HAMMER
CONTROLLING
DEVICES

UNITED STATES
ELECTRIC TOOLS

# Better Yard and Plant Hauling

Ironton Storage Battery Locomotives meet perfectly the hauling conditions in the yards and plants of many steel mills. Dependability, low power cost, simplicity—are its big advantages. Irontons operate 24 hours a day.

Let Ironton engineers study your conditions and make you a guaranty of Ironton Performance under your conditions.

**The IRONTON ENGINE CO.**
**Ironton, Ohio**

# SALAMANDER W. E. Finish

magnet wire is particularly adapted for rewinding field and armature coils, solenoids, etc., and is used extensively in the steel industry. It is acid-proof, moisture-proof, oil-proof, heat-resisting and has an extremely tough, smooth, hard finish.

For further information write to our nearest representative for Salamander wires and cables—

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| Birmingham, Ala. .. | W. H. Beaven |
| Boston, Mass. ..... | Wetmore-Savage Company, 74 Pearl Street |
| Chicago, Ill. ..... | J. D. A. Cross, 213 S. Peoria Street |
| Cleveland, Ohio ... | H. Lee Reynolds Company, 309 Plymouth Building |
| Denver, Colo. ..... | Franklin Sales Company, Denham Building. |
| Los Angeles, Cal. .. | A. S. Lindstrom, 1144 Maple Avenue |
| Philadelphia, Pa. ..... | F. K. Simons Electric Co. Fuller Building |
| Pittsburgh, Pa. ..... | H. Lee Reynolds Company, Oliver Building. |
| Portland, Ore. ..... | A. S. Lindstrom, 312 McKay Building |
| Salt Lake City, Utah.. | Raymond Ackerman, 419 Dooly Building |
| San Francisco, Cal..... | A. S. Lindstrom, 111 New Montgomery Street |
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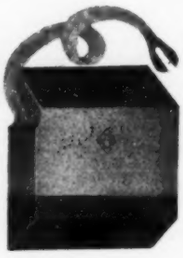
**YORK INSULATED WIRE WORKS**
of General Electric Company

Works: York, Pa. Office: 1737 Broadway, N. Y. C.



## 5 Reasons
## Why USG Brushes
## are
## Extraordinary Brushes

1. Because the graphite used in their make-up all comes from our own mines in Mexico.
2. Because every step in the manufacturing process, from mining the ore to the finished brush, is done by our company.
3. Because our engineers are Brush Experts who have devoted their lives to the perfection and manufacture of better brushes.
4. Because each order is considered separately and the individual requirements of the machine taken into consideration before the grade recommendation is made.
5. Because of the feeling of ease and security which follows the application of U. S. G. Brushes.

USG
***on every brush***

*Write for the list and characteristics of all grades of U. S. G. Brushes.*

**THE UNITED STATES GRAPHITE COMPANY**
**Saginaw, Michigan, U. S. A.**

# MOLONEY
## TRANSFORMERS

WE have been manufacturing transformers now for over a quarter of a century—a long time in an industry so young.

Moloney Engineering Experience has dealt with the transformer in every phase of its development.

From the first, Moloney Engineers have been animated by a two-fold purpose: to build the highest attainable quality, and to build it economically.

Moloney Transformers are recognized by all transformer users as the highest standard—a fact which demonstrates the success which has crowned the efforts of Moloney Engineers.

**MOLONEY ELECTRIC CO.**
***Manufacturers of Transformers Exclusively***
**FACTORY AND MAIN OFFICE**
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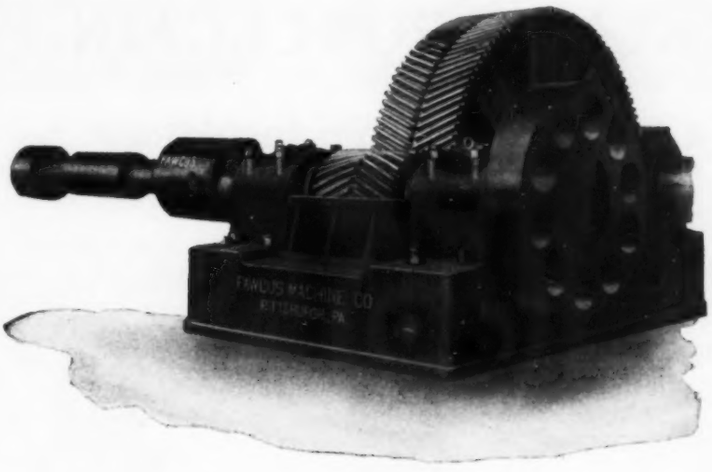
*Offices in All Principal Cities*



# FAWCUS

Herringbone Reduction Gear and equipment designed and constructed by us for the electrification of a 24″ structural mill, replacing a steam engine.

This drive transmits power from a 3,000 Horsepower D.C. motor with operating peak loads of 7,000 H.P. The speed of this motor is adjusted constantly from 0 to 485 R.P.M. and arranged for operating as high as 550 R.P.M. at friction speed.

This equipment was furnished by us complete as shown in the illustration, including the Universal Spindle between the existing engine frame and the reduction gear, also the jack shaft and coupling, etc., leading through the engine to the mill.

## FAWCUS MACHINE COMPANY, Pittsburgh, Pa.

NEW YORK, N. Y., Robt. C. Brown, 84 Pine St.
MILWAUKEE, Wis., L. E. Meidinger
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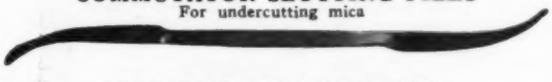
NEW ORLEANS, Southern Jobbers Supply Co.

# Use "Imperial" Commutator Stones

REASON NO. 6—They grind under full speed operating conditions when every bar is held in its true operating position by centrifugal force.

Write for special bulletin. Another advantage will be given next month. 2,840 users on July 1st, a gain of 76 for June.

**COMMUTATOR SLOTTING FILES**
For undercutting mica



**GOODNITE CLEANING TOOL**
For cleaning Commutator slots

***We can supply you with***

Commutator Grinders
Slotting Files
Slotting Machines
Commutator Cement
Insulating Beads
Insulating Varnish
Gauze Wire Brushes
Portable Blowers

THE MARTINDALE ELECTRIC CO.,
11729 Detroit Ave., Cleveland, Ohio.

Gentlemen: Please send me information about your products.

Name and Title .....
(Please print)

Company .....

Street .....

City and State .....

# LAPP HIGH VOLTAGE PORCELAIN

## Did you ever hear of a failure of a Lapp Insulator?

Seven years of production—including highest voltage pin and suspension types —without a failure!

There is the reason for use of Lapp Insulators, besides which—for "trimmings" —they provide unexcelled mechanical strength.

Lapp vacuum process of porcelain production, surfaces of porcelain glazed all over, Lapp over potential test methods.

## LAPP INSULATOR CO., Inc., LeRoy, N. Y.

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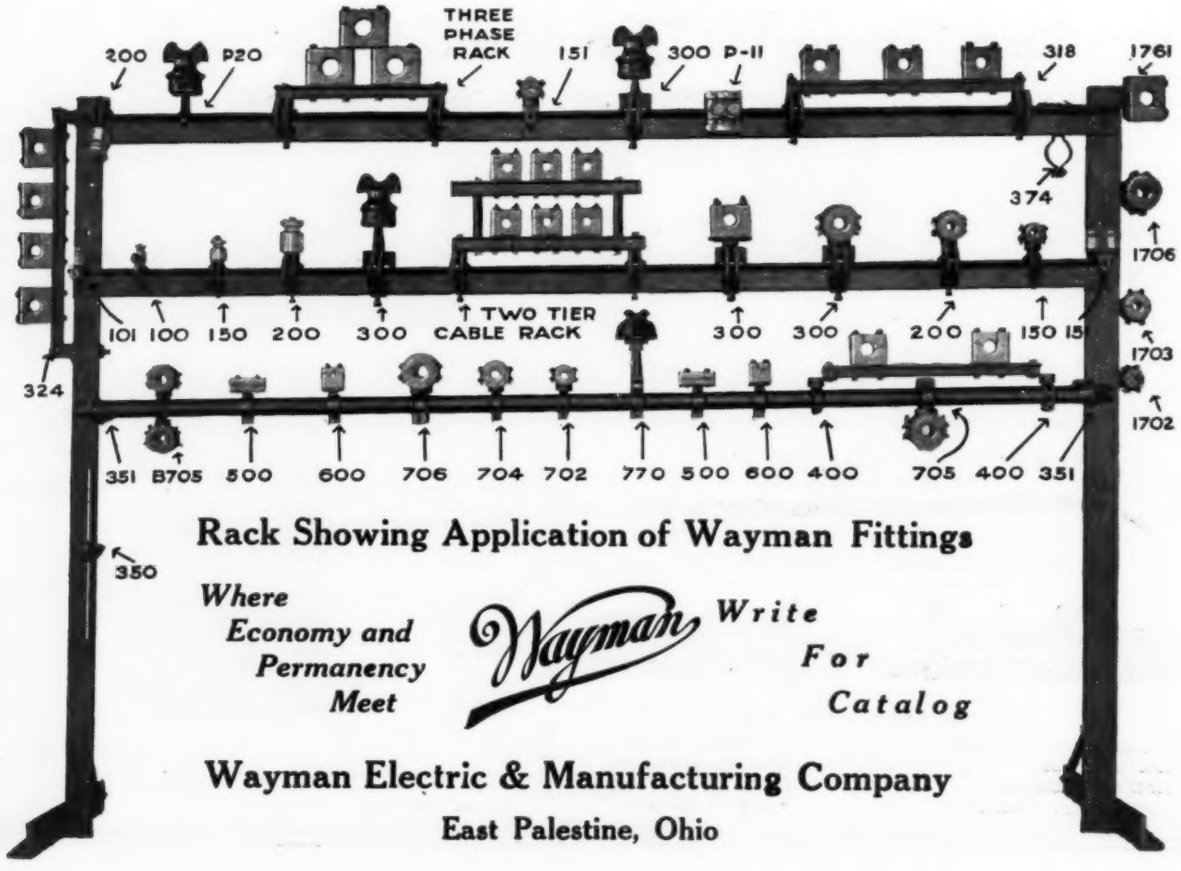
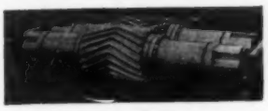



**Rack Showing Application of Wayman Fittings**

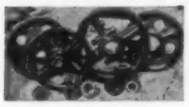
*Where Economy and Permanency Meet* — Wayman — *Write For Catalog*

**Wayman Electric & Manufacturing Company**

**East Palestine, Ohio**

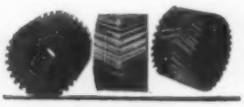


Herringbone Mill Pinions

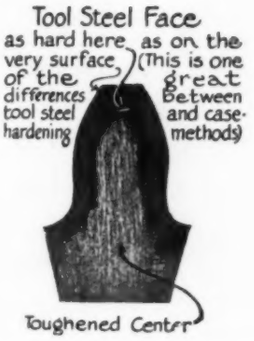


Motor and Crane Gears

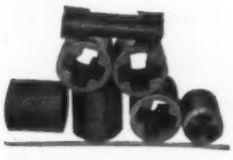
Mill Table Gears



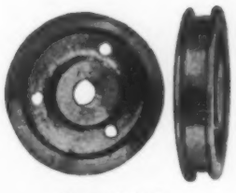
Herringbone Gears


Tool Steel Face
as hard here as on the very surface (This is one of the great differences between tool steel and case-hardening methods)
Toughened Center

Cincinnati "Tool Steel" gears outlast 8 to 10 Untreated and are much stronger



Coupling Boxes and Spindles

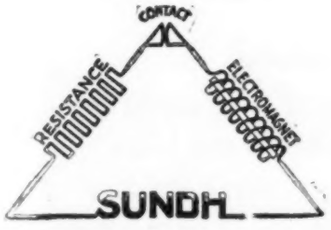


Crane Wheels

# The Tool Steel Gear and Pinion Company

## CINCINNATI, OHIO






# *Steel Men!*

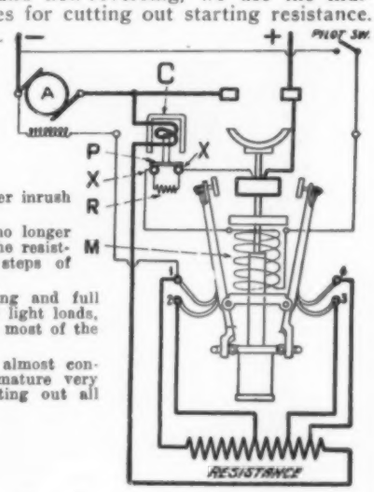
Isn't this what some of you wanted, as brought out in your discussion of control in your Journal of November, 1921? A control that would have definite time limit modified with current limiting element?

You want a starter to obey its real function, don't you? i. e., to start and accelerate a motor by cutting in resistance, then out, in the shortest possible time in relation to the load. You want the motor to "mote" if it's at all possible to do so, whether the voltage is high or low, or whether there is excessive friction on a cold Monday morning. If the first current inrush does not start it, the next one may. If we can't get it to start on small amounts of current, we want to provide automatic means of increasing the current or power so that it will start, provided that no one has placed a crowbar in between the gears or there happens to be a short circuit. In that case, overload circuit opening devices take care of the condition.

We have been using this method since 1911. On large size motor starters, reversing and non-reversing, we use the multiple level starter as a pilot relay whose multi-contact energizes large shunt wound switches for cutting out starting resistance.

The action of this control is easily understood from the diagram, and the following description of operation:

The relay C is in series with the armature only during the starting period and is normally set to operate at about 130% of normal current. When the current in the armature of the motor equals or exceeds this setting on the starting inrushes, the armature of the relay lifts the plate P from the two contacts XX and by this action inserts the resistance R in series with the solenoid coil M of the automatic starter. The resistance R can be made to have a resistance so that when inserted in the circuit of the coil M (by action of excess load on the armature of motor at start) it partly destroys the effective magnetic pull of coil M and prevents the cutting out of any more resistance in the armature circuit, but at the same time there is sufficient magnetic pull to lift the core very slowly so that in time, even with the insertion of this resistance in the magnet coil circuit, the next succeeding step of resistance will be cut out, giving a larger inrush current to the motor.




Under normal conditions as soon as the current in the armature reduces to about normal, the coil C can no longer hold up plate P and it consequently drops, thus closing the circuit across contacts XX, and short circuiting the resistance R, allowing coil M to be again fully energized and to act with full power, thus cutting out succeeding steps of resistance quickly.

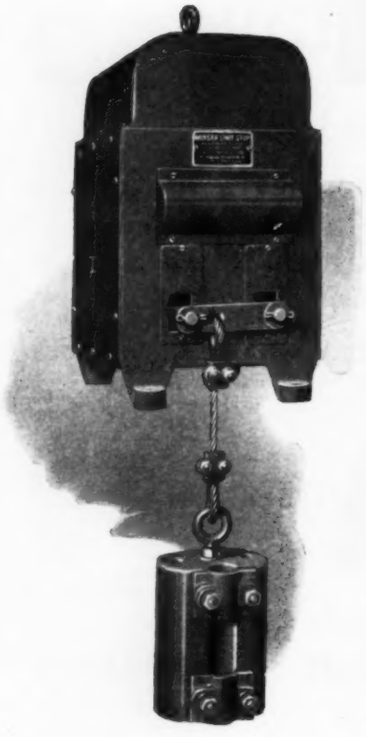
The retarding action caused by excess load on coil M may take place during any interval between starting and full running position. The time of the dash pot is generally set for a minimum of 1½ seconds, which in case of very light loads, the cutting out of resistance would take approximately this time, since the series relay coil C plate XX, would be most of the time short circuiting the resistance R.

Under abnormal, extremely heavy loads, where the series coil C would lift its armature and hold it up almost continuously, thus inserting all the resistance in the coil, R circuit on automatic starter coil M would lift its armature very slowly against the action of the dash pot and light pulling force, and may take up to 15 seconds before cutting out all resistance.

The resistance R may be made of a value as to either increase or decrease the pull of magnet coil M.

***Write for Catalog.***

## SUNDH ELECTRIC COMPANY Newark, N. J., U. S. A.



# Morgan Safety Limit Stop

WACKERLY TYPE

**For All Types of Direct Current Motors**

A FEW OF THE ADVANTAGES

No heavy current broken by contactors.

Limit Stop can be connected up with any standard make of controller.

No extra conductors required.

Normal lowering circuits established immediately upon reversal of controller. No waiting to lower through resistance.

No external banks of resistance. Limit Stop is self contained.

Only one swinging weight used, this being guided by one of the hoisting ropes.

Positive in action. A movement upward of weight of a fraction of an inch will actuate limit stop.

Occupies minimum floor space on trolley.

Sequence of operation of contactors obtained by simple system of levers. No cams, springs or counterweights used.

***For full particulars on this stop send for Bulletin No. 29.***

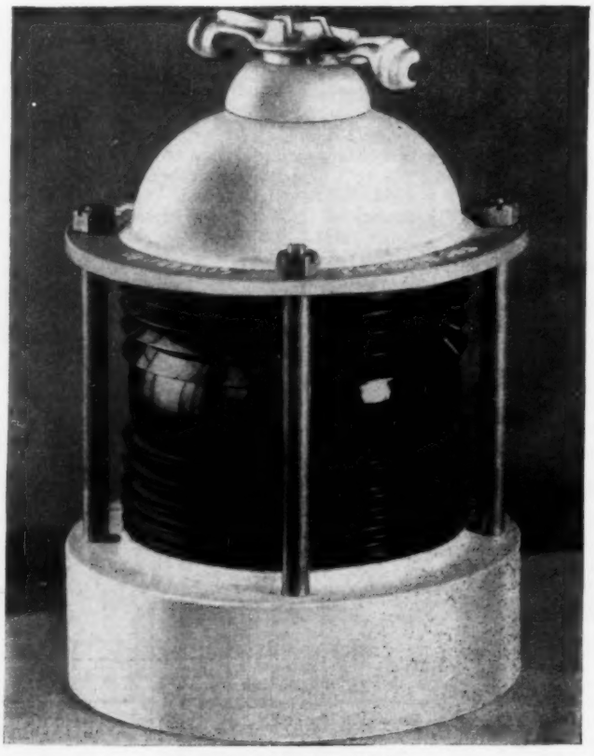
## The Morgan Engineering Co.

**Alliance, Ohio**

CHICAGO
122 So. Michigan Ave.

NEW YORK
120 Broadway

PITTSBURGH
1420 Oliver Bldg.



*"It takes Sand to Win"*

# *Introducing The "Universal" Family*

**A new family is here—the Universal Lamps**

Every member is handsome, strong and industrious and is looking for permanent employment as a warning signal in mills, at street intersections, railway crossings, stops, curves, bridges, in fact, *at any point where a danger, caution or clear signal is needed.*

This is "Big Boy" Universal, head of the house. His height is 16 inches and he does a big lamp's job—in a newer and better way, because he's rugged as all out-doors and he defies weather, acid atmosphere and roughest handling. He's made of cast aluminum — that's his secret strength, which does away with battered, corroded frames and with the elaborate "hanger" preparations that are usual with big, far-vision signals.

He dresses neatly in an 8" Corning Fresnel lens of ruby, green, yellow or clear. He has an adjustable lamp socket and carries a second bulb below as a reserve and for ground illumination. He comes with a span wire hanger or fitted for 1" pipe suspension, as desired.

We'll introduce another member of this popular family in the next issue of this publication. If you are anxious to meet the whole family at once, or think you have a job for "Big Boy", drop us a line and we'll send you the complete family history.

**THE NICHOLS-LINTERN COMPANY**

**7950 Lorain Avenue, Cleveland, Ohio**

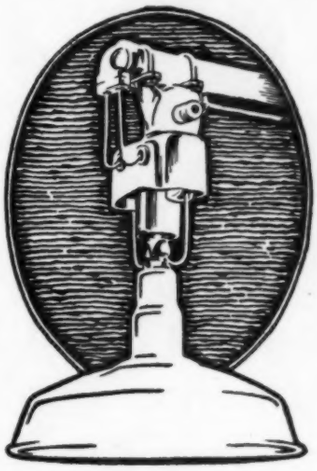
Canadian Rep.: R'way & Power Eng. Corp., Toronto, Ont.

**THOMPSON**

**Safety LOWERING Switch**

**or Disconnecting Hanger**

**"Teco" Underslung Model**



makes

**Lamp Maintenance**

**Accessible**

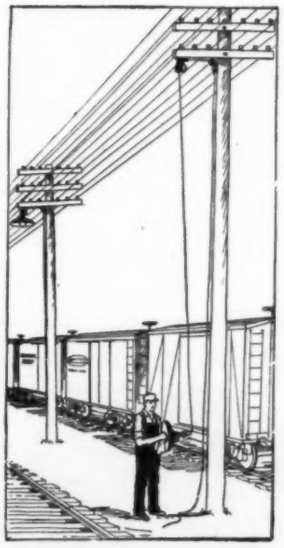
**with**

**Ease and Safety**

**for both indoor and outdoor use—easily included in present lighting systems.**

*Get Catalog B-22*

*Safe*



*Logical*

**The Thompson Electric Co.**

**226 St. Clair Avenue, N. E.**

**Cleveland, Ohio, U. S. A.**



# Claims — or Results?

All kinds of claims may be made about the good points of a fuse. But the things that talk loudest are its ability to stand up under blowouts, and construction that makes renewal easy.

## 'UNION' Renewable Fuses

are daily demonstrating their ability to withstand more blowouts than any other make. And comparison quickly proves they're the easiest and quickest fuses to renew. Hence the

**"Union" Saves More Than ANY Other Renewable Fuse**

Approved by Underwriters' Laboratories. Sold by leading dealers and jobbers.

***Write for Catalog***

**Chicago Fuse Mfg. Co.**

**Manufacturers also of Switch and Outlet Boxes, Cut-Out Bases, Fuse Plugs, Fuse Wire and Automobile Fuses.**

**CHICAGO NEW YORK**

REG. U.S. PAT. OFF.

UNION

# Check These Advantages

1. The only renewable fuse using a powder-filled element fully approved in all standard sizes of both voltages.
2. Each Trico Renewable Element is composed of a fusible link surrounded by a finely divided arc-choking powder, encased in a kraft container which is virtually a fuse within itself.
3. This powder-packed element makes the Trico Renewable Fuse more efficient than any other kind because the fuse link is supported and kept in shape when heated during momentary overloads, preventing premature "blowing" and consequent expensive shutdowns.
4. The casing cannot be charred as the powder-packing chokes the flash of the melting fuse link, preventing pitting of metal terminals or blades, eliminating blackening and heating of contacts so that the Trico Fuse is the easiest to renew.
5. FIRST to adopt air cushion principle, surrounding all parts of fusible element. (Cool and noiseless operation.)
6. FIRST and ONLY renewable fuse to adopt copper terminals on all knife blade renewal elements. (No heating at terminal bolts.)
7. FIRST and ONLY Renewable Fuse to adopt insulated indicating tab. (Fusible link is not exposed.)

Fully Approved

With All Their Features TRICO FUSES COST NO MORE!

TRY TRICO TODAY

*Ask for address of nearest sales office*

The TRICO Powder-Packed Plug Fuse

*Have you tried it?*

TRICO FUSE MFG CO.
MILWAUKEE, WIS.

TRICO FUSES
REG. U. S. PAT. OFF.
Renewable Cartridge

# CROCKER-WHEELER

*Built in 1886 by Messrs. Curtis, Crocker and Wheeler. A milestone in industrial history—the beginning of the electric motor manufacturing industry of today.*

## Three men who made a motor you can't buy

It's a heavy, clumsy thing—just an old, work-scarred "bipolar" of long ago. Yet, it's a priceless motor, carefully preserved and guarded—for it is rich in history. Today, as far as known, only one other of its kind exists.

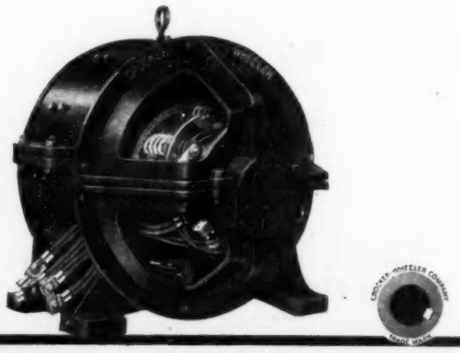
Three electrical pioneers of courage and foresight made this motor in 1886—Charles G. Curtis, Francis B. Crocker and Schuyler S. Wheeler. It is the product of the world's first electric motor manufacturing plant—a member of the very first lot of motors manufactured on a commercial basis.

Two years later, in 1888, Francis B. Crocker and Schuyler S. Wheeler founded the Crocker-Wheeler Company. Building on the solid foundation of their incomparable experience, this pioneer company constantly presses on to new achievements.

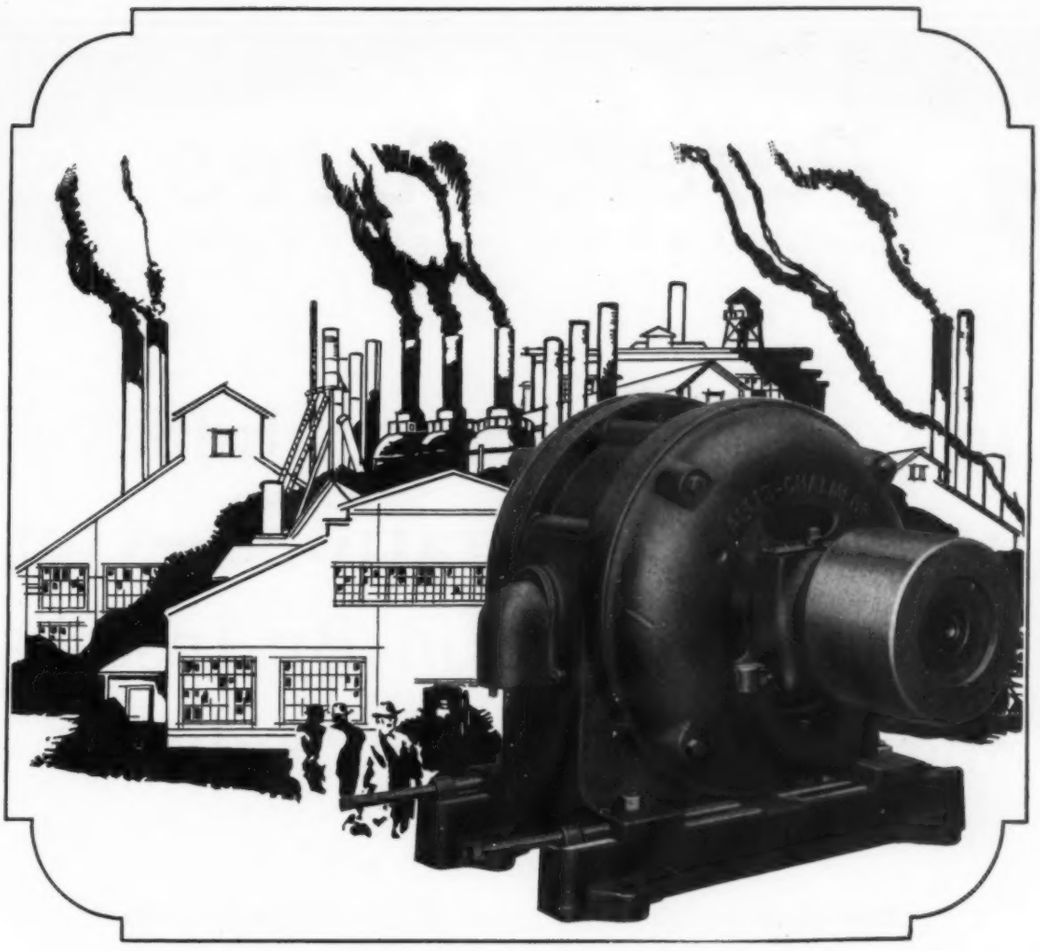
CROCKER-WHEELER COMPANY
AMPERE NEW JERSEY

| | | |
|---|---|---|
| BALTIMORE | CHICAGO | NEW YORK |
| BIRMINGHAM | CLEVELAND | PHILADELPHIA |
| BOSTON | DETROIT | PITTSBURGH |
| BUFFALO | NEW HAVEN | SAN FRANCISCO |

*Foreign Distributor: International Western Electric Co.*



MOTORS & GENERATORS



# *The Type "AR" Has a Broad Range of Industrial Usefulness*

Allis-Chalmers Type "AR" Motors are of special interest to Plant Executives and Maintenance Men because of their all-steel construction, and the simplicity which results from unit features of design. For example, the stator end frames and feet are cast as a unit from electric steel. This insures great rigidity and eliminates breakage.

Intelligently selected for specific needs the "AR" has tremendous adaptability. It is capable of handling the stiffest assignment without faltering day in and day out for long periods. It is built for hard service and trying conditions and it does the job wherever put. Built in sizes from ¾ H.P. to 200 H.P. for all the standard voltages.

Send for Bulletin No. 1118C

ALLIS-CHALMERS PRODUCTS
Electrical Machinery
Steam Turbines
Steam Engines
Gas and Oil Engines
Hydraulic Turbines
Crushing and Cement Machinery
Mining Machinery

ALLIS-CHALMERS MANUFACTURING COMPANY
MILWAUKEE, WISCONSIN, U.S.A.
*District Offices in All Leading Cities*

ALLIS-CHALMERS PRODUCTS
Flour and Saw Mill Machinery
Power Transmission Machinery
Pumping Engines-Centrifugal Pumps
Steam and Electric Hoists
Air Compressors - Air Brakes
Agricultural Machinery
Condensers

STORM, RUST & GAS PROOF

CAST ALUMINUM ALLOY BUILT TO LAST

# Pyle-O-Lytes

and STEAM TURBO-GENERATORS

## Turn Midnight Into Midday—Speed Up Operations—Get Greater Production By Installing Pyle-National Products

***Pyle-O-Lytes***

***A wide range of types and sizes for every flood-lighting requirement. They speed up night work and increase the efficiency of men and equipment. Cases built of long-lived cast aluminum alloy that will outlast many ordinary sheet metal units--storm, gas, and rust proof.***

***Steam Turbo-Generators***

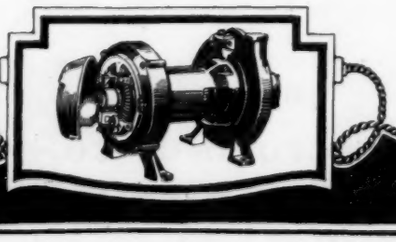
***Pyle-National Steam Turbo-Generators are furnished in five types, with capacities ranging from 500 watts to 7½ K. W. Their consumption is less than that of any other turbo-generator of equal size and capacity.***

*Write for Catalog No. 4.*

**The PYLE-NATIONAL COMPANY**

**1334-58 N. KOSTNER AVE., CHICAGO**

General Offices and Works:
1334-58 N. Kostner Ave.
CHICAGO



In Canada:
The Holden Co., Ltd.
Montreal, Winnipeg, Vancouver, Toronto

## INSIST UPON THIS TRADE MARK

ON EVERY HERRINGBONE GEAR YOU BUY

This Trademark Guarantees

That Gears Are Generated on Sykes Machines

Continuous Teeth—Sharp Apex Points

Finest Materials Used—Best Workmanship

## THE GEAR WITH A BACKBONE

---

## FARREL FOUNDRY & MACHINE CO., Inc.

### BUFFALO, N. Y., U. S. A.

NEW YORK CITY
SAN FRANCISCO, CAL.

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BOSTON, MASS.
LOS ANGELES, CAL.

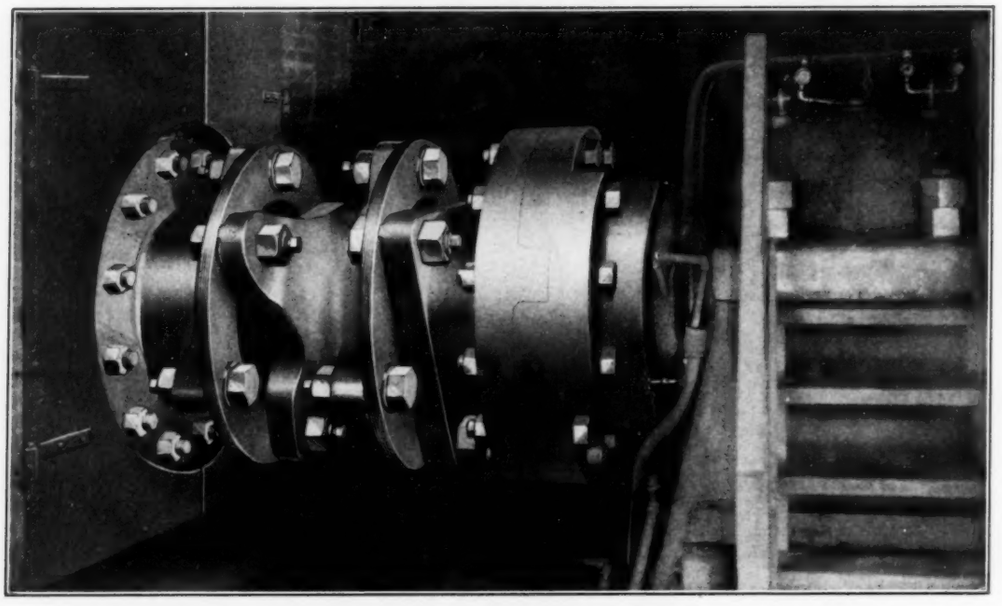
*Plants Located at*

BUFFALO, N. Y.

ANSONIA, CONN.

# THOMAS FLEXIBLE COUPLINGS

## FOR MAIN ROLL DRIVES



**Thomas Mill Type Coupling on 84″ Plate Mill, 2500 H.P., 235 R.P.M.**
**Youngstown Sheet & Tube Company**

Above coupling and another on the 5,000 H.P. 197 R.P.M. 132″ plate mill drive at this same plant have operated a total of six years with absolutely no maintenance charge.

No sliding or wearing parts
No loosely connected members
No frictional resistance to end float
No lubrication
Three very accessible bolts, removal of which frees either end of drive

The Thomas coupling is the only mill spindle which has these features. The first two are the most important, as a "tight" drive eliminates all backlash and prevents the hammering action, which is so destructive to gears, bearings and shafts. The net result is an immediate reduction in maintenance costs.

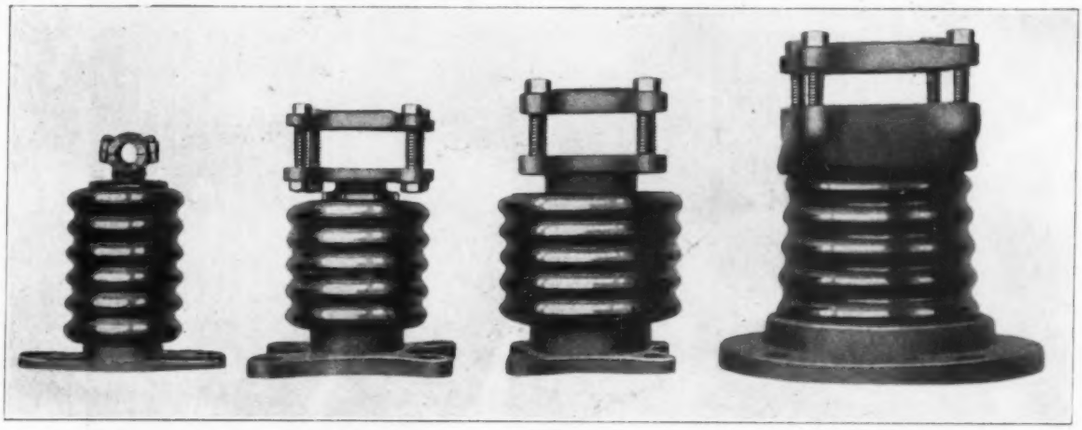
## Thomas Flexible Coupling Co., Warren, Pa.

**SALES OFFICES: Pittsburgh Chicago Cleveland Philadelphia Boston St. Louis New York Springfield**

THE STANDARD OF COMPARISON

# The Delta Star

UNIT TYPE



Diameter 3¾ inches | Diameter 4¾ inches | Diameter 6 inches | Diameter 6½ inches

## Advertising Made Him Forget

A few days ago a well known public utility engineer was at our factory inspecting some 132,000 volt equipment being built for his company. He seemed surprised at our large volume of bus support business—in fact, had the impression that we did not particularly care for this class of business.

This was somewhat of a shock to us, so we asked him point blank where he got such an idea. It developed he is a close reader of technical advertising and the large amount of space we devote to outdoor equipment had created this impression.

As a gentle reminder to others who may, also, have forgotten, we illustrate above just a few of our indoor bus supports for standard heavy and extra heavy duty.

We have thousands of indoor supports, switches, and other combinations—so if you, also, have been too much influenced by our outdoor equipment advertising—give us an opportunity to quote on your requirements—we can give you Unit Type throughout. Our opportunity will be yours.

We know our Bulletins will interest you. Why not send for them—today?

**DELTA-STAR ELECTRIC CO.**
**2400 Block Fulton St Chicago, Illinois**

934 Union Trust Bldg. PITTSBURGH
1333 Real Estate Trust Bldg. PHILADELPHIA
2433-61 Fulton Street CHICAGO

**UNIT TYPE CEMENTED SWITCH INSULATORS**

Packard TRANSFORMERS
For Every Service

They are built to render but one kind of service—the best.
Get a Packard proposition when next in the market.

The Packard Electric Company Warren Ohio

Transformer Manufacturers Since 1890

# AIR!

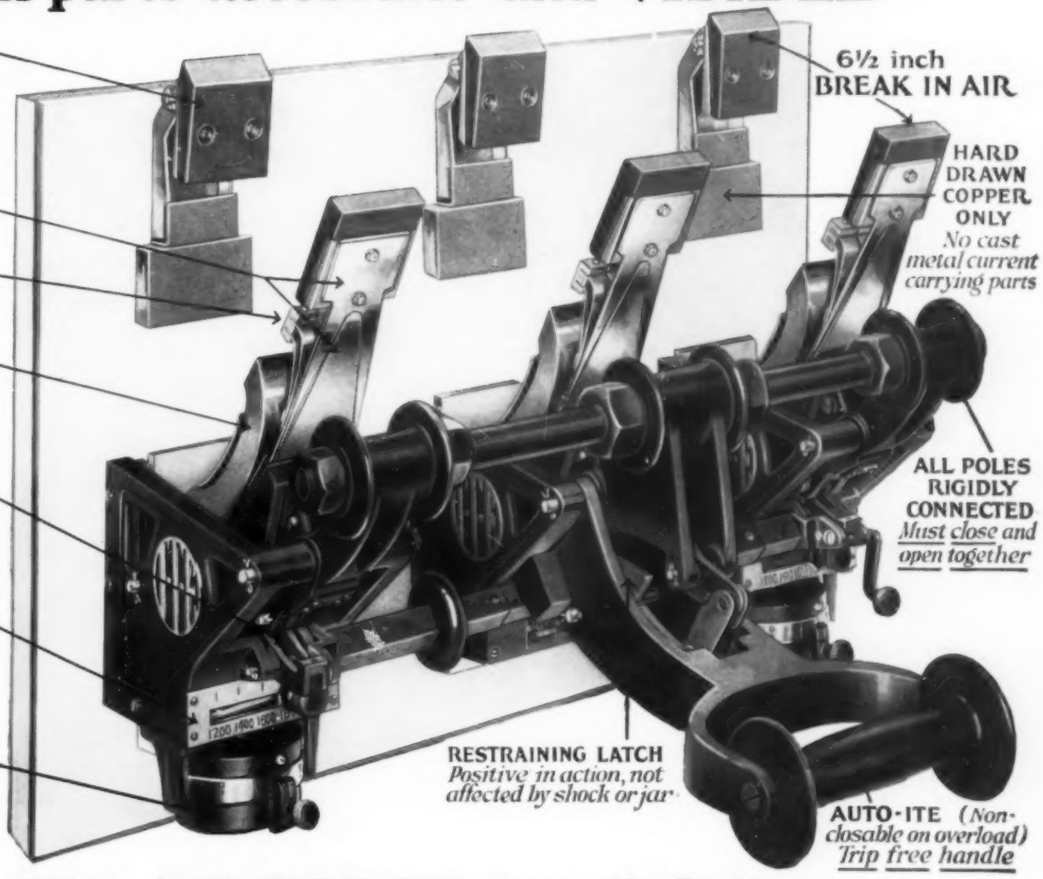
# I-T-E CIRCUIT BREAKERS

*For Alternating Current*

## 600 VOLTS OR LESS

## Give protection without complication

## All parts accessible and VISIBLE

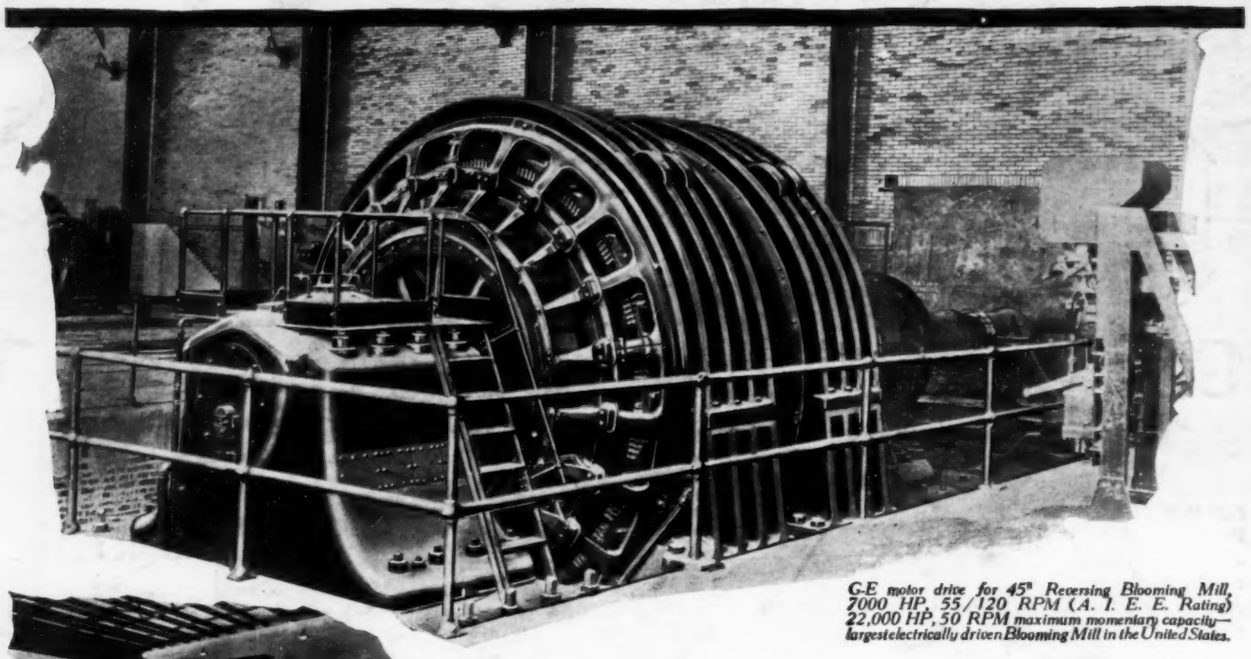

COPPER JACKETED PRESSURE CARBONS
For initial contact and final break
Mechanically strong
Electrically perfect
PHOSPHOR BRONZE CARBON SUPPORTS
HEAVY METALLIC SECONDARY BREAKING CONTACTS
LAMINATED BRIDGE
Each leaf individually formed - Heavy even pressure on every Lamination
CLOSING TOGGLES
Afford heavy contact pressure with easy closing
OVERLOAD
Direct acting. Long scale calibration. No relays or series transformers
DALITE
(Direct acting time limit) feature. Adjustable from zero to maximum time. No relays
6½ inch BREAK IN AIR
HARD DRAWN COPPER ONLY
No cast metal current carrying parts
ALL POLES RIGIDLY CONNECTED
Must close and open together
RESTRAINING LATCH
Positive in action, not affected by shock or jar
AUTO-ITE (Non-closable on overload)
Trip free handle

## I-T-E AIR BREAK has definite advantages not present in the oil breaker

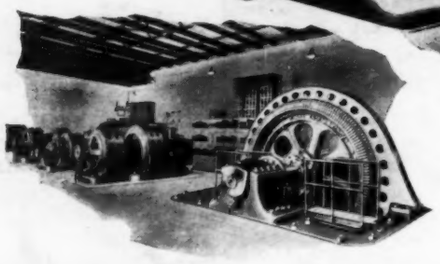
1. *No oil — to leak, carbonize, burn or explode — Just air.*
2. *No tanks to conceal anything — or the lack of it.*
3. *No cells — nothing which needs or deserves to be imprisoned — Just a faithful and efficient servant.*
4. *Inherent simplicity — with resulting low cost of installation and maintenance.*

The I-T-E CUTTER COMPANY

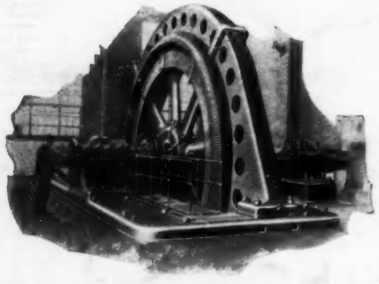
ESTABLISHED 1888 PHILADELPHIA



*G-E motor drive for 45" Reversing Blooming Mill, 7000 HP, 55/120 RPM (A. I. E. E. Rating) 22,000 HP, 50 RPM maximum momentary capacity—largest electrically driven Blooming Mill in the United States.*



*G-E adjustable speed motor rated 1800/1500/1200 HP, 240/200/160RPM—driving finishing stands in 10" Hoop Mill.*



*G-E motor—2500 HP, 82 RPM, 6600 Volt—with breakable end thrust driving Roughing Rolls in Structural Mill.*

# G-E motors—true as steel

IN the leading steel mills operating main rolls with G-E motors and control devices, costs reduced through increased tonnage—lower maintenance charges—quality improved through better control, are actual performance records which show the advantages of installing G-E equipment.

The requirements of main roll drives which are being successfully met by G-E motors and control are:

Constant Speed Mills for sheet and plate mills—driven by single speed motors, usually of induction type.

Adjustable Speed Mills for strip mills and merchant mills—driven by adjustable speed induction motors with either Scherbius or rotary converter control, or by direct current motors with Ward-Leonard or motor field control.

Reversing mills—driven by direct current motors with Ward-Leonard control, or with combination of Ward-Leonard and motor field control.

The choice of the particular type of drive for any steel mill can best be determined after consideration of the factors affecting the problem by steel mill specialists of the General Electric Company. Ask our nearest office for co-operation which will be gladly given.

**General Electric Company**
**Schenectady, N. Y.**
**Sales Offices in all large cities**

# GENERAL ELECTRIC